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THE PROPOSED AQUEDUCT FROM THE COLORADO RIVER[1]

BY WILLIAM MULHOLLAND[2]

Preparatory to the introduction of the subject assigned to me, that is, the proposed aqueduct from the Colorado River, I will have to precede whatever remarks I have to make on that topic by first pointing out the necessity of such a project. It is all very well to say, "We will bring water from the Ganges or the Brahma putra," but first we must show the need of it to our patrons, the public. Before going on to that point, I want to say something about the impressions I received and about the various meetings of this organization today. I have always held very strongly for Christian principles (I am not going to preach a sermon, however); always having held that the amenities of civilization require that people meet in close association. I met possibly one hundred people of this group today; they are commonly, when I meet them, in the attitude of rivals and in a hostile attitude to each other when they meet in my office; they are rival bidders upon machinery and water works appliances; they always come in with a scowl when they meet the other fellow there and although always refraining from anything discourteous, just the same there is always that spirit of hostility.

[1] Presented before the California Section meeting, October 28, 1926.

[2] Chief Engineer and General Manager, Bureau of Water Works and Supply, Los Angeles, California.

I have often wondered whether it could be eliminated and I found today that it could be by the appliance of Christian principles. I saw more Christian principles today than I ever saw exercised in my whole experience. I once knew a man who followed those Christian principles; he believed in the rules of propinquity and the fact that a close association and intimate knowledge of the character of those with whom he came in contact always brought about a better understanding; that man was unfortunate enough to lose his wife in early years—a great misfortune to him, but he turned around and married his mother-in-law. Now, all of these men today, I notice, were in a mood, should they be bereaved in this way, to really turn around and marry their mothers-in-law.

Before proceeding with the subject of the Colorado River, it is proper that we should show some reason for the venture. For that reason I wish to advert a little to the present condition of the city of Los Angeles and to the motive that impels her to look so far distant so soon after the great adventure of some twenty years ago, to-wit: the building of the Los Angeles Aqueduct. I was the sponsor of that project as I am of this one. Being responsible for this project and considering the necessity of the occasion as at the end of the drouth following the years 1902–3, we were at our wits end for a water supply in the city of Los Angeles and there was an impending shortage. If the drouth had lasted another year or two that would have ended the city of Los Angeles. We were afraid of that, but a normal rainfall came and we got along for another ten years or so by reason of the fact that there was a restoration of the normal precipitation. We are now, I hope, near the end of another, a very disastrous and long continued period of drouth. We all know,—all of you who study the water supply of this district, that we are on tenterhooks as to where the next year's supply is coming from, or the year after that, and you all know that we have had a drouth of very drastic and fierce persistence up and down this State. The ground waters have receded; the streams have dried up; the lakes have dried up and all of the rest of the things have happened until the water situation leaves us on the verge, not of total destruction, but of great distress. If we do not get a rainfall within a year or two this city will suffer a knockout blow for many years that will suppress and check many useful projects for the public weal in this State.

This matter was presented to the city of Los Angeles as it was to the city of San Diego and every other city up and down the coast from

San Francisco,—even from the Siskiyou clear to San Diego and even further north.

To my great surprise the cities of Portland and Seattle are also complaining, not on account of any insufficiency of the water supply which is within striking distance of those cities, but the storage facilities for their respective water supplies were not adequate to meet the conditions of drouth that have presented themselves within the last few years. We have to be forehanded. Of all other professions in the world, the man with the responsibility of supplying a city with water has to be forehanded. He must look ahead and look a long way ahead, discounting every possible sort of condition that may arise. You cannot get up in my position—and many of you know the position I am in here—you cannot get up and make excuses to your employer, your public. You must guess your crowd, plunge, go ahead and for their welfare provide an adequate water supply. It is allright if they reject your proposals. You are excused. But if you do not present the matter in a positive way to the people and some disaster occurs, you are at fault and you cannot evade the responsibility.

The people of the city of Los Angeles are not acquainted with the disaster that impends by reason of her prosperity. Prosperity is not always good, it gets people off the alert and they disregard a proper sense of security.

The major part of the city of Los Angeles is located south of the Santa Monica Mountains. There are frequent checks made from time to time to determine the tendency of the city's expansion. The people in the city of Los Angeles have not induced that tendency. It is the people lying outside of the city of Los Angeles that want to pull the blanket over their feet to obtain a share of the water supply. There is scarcely a month passes that we are not appealed to by people around the rim, much to our resistance,—for what?—to get a share of the city's water supply. Now we have had to extend and extend until at the present time the area of the city of Los Angeles is 430 square miles. That is the size of the city we have to supply and you will all appreciate the fact that it does not make for a cheap water supply or water works.

The population, as determined by many observations, at the present time is more than 1,200,000. The population of the city per square mile is 2700. Imagine a diffused population like that spread over such an area. To provide a city of that size with water re-

quires 2800 miles of main pipes; more than one-tenth of the distance around the world. The mileage of main pipes in the city has been doubled within the last five years. The number of services is 240,000. The domestic water consumption of the city in summer is 152,000,000 gallons; in winter 123,000,000 and a mean of 138,000,000 gallons per day.

I recall when I first did some work for the northern cities, the consumption of water in the city of Oakland was about 16,000,000 or 17,000,000 gallons per day, the consumption in San Francisco was close to 40,000,000 gallons per day. I do not know, however, what the consumption of those cities is today, but possibly double what it was at that time. Compare that with the city of Los Angeles, with 138,000,000 gallons per day.

The city of Los Angeles is virtually on the edge of a desert. You may go in any direction from the city, north, south, east or west and you will find the desert before you go very far;—the arid, grinning desert.

The city of Los Angeles had to go 250 miles to the north, over three mountain ranges, and across deserts and waste plains to the Owens River to get her last water supply. Why has she outgrown this supply so rapidly? The very fact itself that she got it, attracted the people to our city. It added tremendous prosperity and attractiveness and brought people here.

I recollect when I was campaigning for the bonds for that water supply, people would ask, "How long will that last you?" I believed fully in the growth of the city, but never felt it would reach its present proportions in such a short span of years. I am, and always was, the greatest pessimist on the question of the growth of the city of Los Angeles and I hope she stops tomorrow. But she grows in spite of me. Yet people would ask me, "How long would that last?," and I would say, "It will last until she grows—until we have a population of one million people; as soon as we get a million people we will have to seek another water supply."

We now have a million and one-quarter population and we are still living on the old water supply with the population still increasing as rapidly as ever and very naturally I am still in the same nightmarish state of mind as I was thirty years ago.

We pump water in the city of Los Angeles. The criticism offered to the proposed aqueduct from the Colorado River to Los Angeles,

is that we will not be able to pay the cost of pumping this water by the time we get it to Los Angeles. We know what it costs to pump water. Our pumped water at the present time is 80,000,000 gallons per day. That is more than San Francisco and Oakland use, yet we pump that quantity. You cannot scare us with pumping water, if we can get water with no very great taxation but that of pumping.

In addition to that, the Colorado River carries with it the proposition of power development. There is tremendous power to be developed and I will say that we propose to develop it. A quantity of 1500 second feet of water will require just about one-third of the power that can be developed at the Boulder Canyon Dam. You cannot put power to better use insofar as Los Angeles is concerned, or insofar as California anywhere is concerned, than to pumping water for profitable use.

We can pump the water there if we get the power at cost plus cost of operation, say for 5 cents per 100 cubic feet, as we are selling water today in Los Angeles for 13 cents per 100 cubic feet. So it will be seen that there is a good margin before we reach the limit of 20 cents per 100 cubic feet. The cities of Oakland and San Francisco charge 25 or 28 cents per 100 cubic feet and I claim right now that that is cheap water. Why should a man get water, the essential element of life, more cheaply than the cost to him of polishing his shoes or paying for his telephone? The telephone rates in Los Angeles are far in excess of the rates for water. They should not be. We can stand to pay far more than we do at the present time for water. I am not protesting against the existing rates for water in the city of San Francisco or Oakland as I have always found that the rates are perfectly justified. The people who brought the water there and entered the field of supplying those two great cities with it were justified in making the rates which they did. The rates which they made were approved by the State Railroad Commission.

If we can get water into the city of Los Angeles, through an aqueduct, from the Colorado River, for 20 cents per 100 cubic feet, and I am certain that we can, we shall still have a cheaper water than the average large city in the United States. Remember, other large cities that front on rivers or lakes have never had to worry about their water supply. The city of New York had the greatest problem and yet she never went more than 120 miles and there were no moun-

tains to climb. It all came by gravity. She is the only city that had any great water problem; the others just dipped their suction pipes into the rivers or lakes.

You gentlemen are required to contemplate in your every day business, greater problems than any city in the east; you have a more extensive job before you.

The city of Los Angeles is peculiarly situated; the great area to the north of it; the San Fernando Valley is being very rapidly settled; it was used as the dumping ground for the Owens River water pending its need for domestic use, and was used there temporarily until we should know what to do with it.

Our storage facilities for this supply in the San Fernando Valley were too far removed from the city proper for safety, and provision was made for additional storage closer to the city, on the margin of the Santa Monica Mountains, where we now have a storage free from any risk of interruptions. These reservoirs are very capacious, having an average capacity of 30,000 acre feet with supply mains running right into the city.

The insurance companies used to wonder how we were going to safeguard our water supply. There is not a city in America whose water supply is so completely safeguarded against interruptions. Why? Because it was built with that end in view. We have thirteen mains leading into the city and do not depend upon any one main carrying water from a remote source of supply. I am not taking any particular credit; however, my organization is to be thanked for it. The thing seemed to be suggested naturally and it was so built. I think it is the Bible or the Koran or other high religious authority that said: "He who bloweth not his own bazzoon the same shall not be blown."

The new project embraces the territory lying between the Colorado River and the Pacific Ocean southerly of the Boulder Canyon Dam site. The ostensible first route was surveyed for the aqueduct to convey water from the Colorado River. Since we started on the surveys for this route we resolved not alone to survey that line but the potentialities and possibilities of other directions to get a cheaper line. We started broadcasting and within certain boundaries, including the entire Boulder Dam Country clear over to the Grand Canyon of the Colorado, we closely surveyed every bit of the area and it will be shown in our complete topographical map. This entire country is worked out into a model relief map so that we can

stand in front of that map and plot any route without leaving our office. Every bit of it has been traced mile by mile. We found out where tunnels and siphons will have to be built and where the ground is too high or too low. It is the most monumental piece of work of its kind ever constructed and is within a month of being completed.

The direct route from Blythe to Los Angeles is the one that requires the least tunnelling; it is the one that comes out with the higher point of delivery. I will not deny the fact that I am in favor of that route. I do not like to boast about the discovery, but if you turn a jack-rabbit loose at the Colorado River and head it for Los Angeles, and scare him enough, he would go via that route.

The Governor of this State, shortly before election, announced that he and his engineers had discovered a shorter route for the Colorado River Aqueduct. I do not know how he found it up there in his office at Sacramento. Neither have I been able to verify such statement from his engineers. On the contrary these gentlemen, whom I know well, spent ten or twelve days with me all over that desert country and have informed me that they made no such claims.

We can take our map and draw a line along any route that may be proposed by a normal person, as a substitute for the route we have. We did that to guide the people in their judgment and estimamation of our ability to lay out the line. If they can find any way that this line can be shortened, decreased in cost, or increased in efficiency, we are willing to let them do it that way and the map will be before them.

I think it is a great thing that the city of Los Angeles has not been discouraged by the shortage of the Owens River Aqueduct supply (due to the prolonged drouth affecting the entire coast area), but have turned to this new project.

The Los Angeles Aqueduct cost us a bond issue of $153.00 per capita. We had at that time 160,000 people in the city of Los Angeles. Now that did not scare the people. They went to the bat and built the aqueduct receiving their benefit in the shape of billions of dollars in increased value to the real property alone, which paid for the aqueduct many times over. That debt is a little over one-third paid off at this time and we are going to undertake another debt. The estimated cost, in the rough, is between $150,000,000.00 and $200,000,000.00. It will not cost as much per capita as the

Owens River Aqueduct. The city is proportionately larger than it was then so it is therefore not a great undertaking.

I reasoned these things out—soothed myself. I am itchy about it. I am afraid to talk about that much money as I was brought up by frugal people in Ireland and there was not that much money in all Ireland I am sure. At any rate, it will be about that sum and I do not think the people need fear to incur the debt, nor do I believe the people will have any such fears.

The people of Los Angeles are a canny kind of folk but where they can see a profit they are going to invest—you can depend upon that.

San Francisco is a city for which I have always had great admiration in every way. She has been burned up; shaken up; and the people turned to and rebuilt her within a couple of years and then turned around and staged a fair the equal of anything in the world. But there is something about her not the same as Los Angeles. She is not a practical city; the people cavil and do not get together on material things. They undertook the Hetch-Hetchy—there is something providential about the city of San Francisco—there is something that seems to look after her. She has never suffered a water famine and some of us who know about the water works condition of that city, marvel how the water works men of that city can go to bed nights and sleep; they have been on the verge of disaster for several years. They have a wonderful project in San Francisco, the Hetch-Hetchy. I have often wondered why they do not call it the Itch-Itchy because they have been scratching themselves about it for thirty years. As a matter of fact they began work on it ten years before Los Angeles undertook the construction of the Owens River Aqueduct. They can remedy that; they are proud, fine people and many of them who hear my remarks tonight will no doubt write me very indignant letters, but I am telling you what is the truth, that the people of the city of Los Angeles are not that kind. They do not compare in many ways in romanticism or chivalry with the people of San Francisco, but they can get together and do a job of work,—just authorize them to do it.

THE CLEVELAND RESERVOIR[1]

By Elbert Peets[2]

Our drinking water, in Cleveland, is stored in a covered reservoir. The reservoir keeps the water clear and cool, and to do that as effectively and economically as possible is its only reason for existing. Quite incidentally, it is an architectural masterpiece.

It is called the Baldwin Reservoir. (Actually there are two, but I shall use the singular number because they are exactly alike.) It is a subterranean room about five hundred feet square, surrounded by concrete walls, paved with concrete and covered with a roof of intersecting flattened barrel-vaults of concrete carried on round concrete piers. The crown of the vaults is forty feet above the floor. The piers, which are thirty inches thick, are about twenty feet apart both ways. The only openings are a few small manholes in the ceiling.

The beauty of the Great Hall of Cleveland is first of all in its vast extent—its six hundred columns, its fifty aisles. But it has delicacy, too. The aisles are pleasantly proportioned in cross section. The columns are spread conically at the floor, an unpleasant shape but at a distance softening into a simplified diagram of an architectural column base. At the top there is a rather bungling transition from round to square to meet the square springing of the vaults, but here again, with almost pathetic lack of affectation, the aesthetic function of a capital is expressed.

There is nothing quite like it anywhere. Each aisle has about the proportions of the side aisles of a moderately high Gothic church, Winchester Cathedral for example, though the flattened vaults remind one of later Gothic buildings such as St. George's Chapel, Windsor. But for the great area, the forest of equispaced columns, the precedents are ancient. That is a hot-climate, Mediterranean idea. The great hall in the temple of Ammon at Karnak was 160 by 320 feet and contained 134 columns. The Hall of a Hundred Columns at

[1] Reprinted by permission from "The Nation," February 9, 1927.

[2] Architect, Co-author with Werner Hageman of "Civic Art."

Persepolis had just a quarter the area of the Cleveland hall, but its ceiling was twenty feet higher.

For the "public inspection" in 1925, before the reservoir was flooded, a few aisles along the west wall were lit by hanging an electric bulb close to the ceiling in every fourth or fifth bay. The rest of the hall was dark save for a few "Jove's eyes" where manholes had been left open. The warm yellowish electric light spread out from each of the lit bays and laid a net of radiating column shadows on the floor. The curved shapes of the springing vaults, caught by the shadows of the vaults nearer the lights, produced a fantastic mosaic of interwoven spots and lines varying from bright gold through every shade of warm gray to deep soft black. The columns were halved and quartered by the shadows of other columns or were picked out of the darkness by narrow tangent strips of light.

In search of new aspects I wandered out from the lit bays into the dark forest of columns. A dozen bays deep in it, when I looked back along an aisle I saw a bluntly bullet-shaped area of warm gray concrete wall, streaked with vertical shadows and framed by the lighter lines of the more directly lit columns near it. Nearer me the columns became less and less light. There was a similar gradation of light in the ceiling, not uniform but flecked with light and dark as rays or shadows caught the surfaces of the groined vault. Across the bottom of this deep stage-setting moved a line of little people silhouetted against the bright wall, so far away that I could not hear their voices or tell whether they were looking out into the darkness toward me.

Another fine view was from north to south along a dark aisle in which there was an open manhole in the top of the last bay. Everything around me was jet black. In the distance again the bullet shape, this time not of warm light but cool silver, the white light streaming down through the manhole and along the gray columns, spreading out on the floor to form a white line from one base to the other.

The view which had most of "art" in it was a concrete stand-pipe, seen from about two hundred feet away, along the aisle in which it stood. The front of the enormous pipe was lit by an open manhole just above it. The white light flooded down along the gray cylinder, broken only by the black drooping shadow under a flange-offset ten feet from the top. Each side of the cylinder darkened into shadow, but just at the turning was a pale line of ruddy light from the electric bulbs. On the floor some ponderous valve-affair served as altar and a

dark crowd of pigmy worshipers stood with heads uplifted as the high-priest chanted "Ten million cubic feet, two million dollars." . . . . Everywhere I was surrounded by a star or diagonal vistas, narrower, more sharply crowned, more Gothic than the full views down the aisles.

No architect ever lived who would not stand in silent wonder in this Hall of Six Hundred Columns. It is an abstraction, a song in some nameless mother-language that everyone understands. It is the work of a law, of a formula ruling over space and mass—rather, perhaps, a law brought into the range of our feelings by being stated in the most fundamental, most simple terms of human need for formal perfection. It is the product of man's desire for order, freed from the old conventions of architecture by the new conventions of engineering.

The great beauty of the reservoir is its simplicity and purity. Nothing is petty, nothing is irrelevant, nothing is boastful, nothing tells a story, nothing mumbles the names of gods, men, or races—nothing is human. There are no windows, no doors, almost no light, no sign of human use, not even a stone cut small so men could lift it. And yet it is superbly human. Besides it the formless jumble of nature becomes a congeries of wilful antics. It is so human that in an hour it became very dear to me. Its floor's level firmness gives my body the safest and most assuring relation to the earth; the solid ceiling, curving from pier to pier, does not weigh upon me and yet protects me from all the unknown things of the air. The strong round columns seem human, make me feel taller and stronger. My eye follows them as they march away into the shadow and I actually touch and measure and embrace the space that surrounds me. I live at last in a cosmos.

And we built it to cool our drinking water.

THE BALDWIN FILTRATION PLANT[1]

By G. W. Hamlin[2]

The placing in operation of Baldwin Filtration Plant, in the fall of 1925, marked the beginning of supplying all filtered water to the entire district served by the Cleveland Water Department. Prior to this time only a little more than one-half of the entire water supply was filtered at the Division Filtration Plant.

In describing this part of Cleveland's water system, it will be convenient to divide it into four parts, first, the supply of water from the lake; second, the filtration plant proper; third, the storage of filtered water; and fourth, the supply of filtered water to the distribution system.

SUPPLY OF WATER FROM THE LAKE

The water filtered at the Baldwin Plant is obtained from a steel intake crib, located at the end of the Kirtland Pumping Station tunnel, and about four miles off shore. From the intake it flows through a nine foot circular brick lined tunnel 26,047 feet long, to the suction wells of the Kirtland Station pumps. These pumps force the water to Fairmount Reservoir, a former supply reservoir, located at a lower elevation than, and just west of, the filtration plant.

Prior to the construction of Baldwin Filtration Plant, Fairmount Reservoir was used as a supply reservoir floating on the low service district. Accordingly, only a part of the water pumped from Kirtland Station reached the reservoir, as branch mains tapped the feeder mains on the way.

The new plan provided for the replacement of this reservoir by a larger one at a higher elevation, and the use of Fairmount Reservoir as an intermediate storage reservoir for raw water, between the lake and filter plant. The Kirtland Station pumps were to deliver water to this reservoir and then it was to be repumped to the filter plant by low lift pumps in the new Fairmount Pumping Station.

The new use of the reservoir required rearrangement of the mains

[1] Presented before the Central States Section meeting, September 21, 1926.

[2] Engineer of Construction, Water Department, Cleveland, Ohio.

leading from the reservoir and rearrangement and increase of main capacity leading from Kirtland Station.

By cutting out their connections to branch mains, use was made of three existing 48-inch mains to carry the raw water part of the way to the reservoir, and a new 48-inch main was built from the station for a part of the way. From the ends of the four 48-inch mains, two new 60-inch steel mains were laid the balance of the distance to the reservoir.

At the reservoir new control works were provided. Two inlet gate houses, with submerged discharge into each half of the reservoir, were provided to receive the discharge from the two new 60-inch mains.

An outlet gate house was built in each half of the reservoir to control the supply of water to the new Fairmount Pumping Station. Water was taken into these gate houses through screened openings which were connected by shaft and tunnel with the suction header under the low lift pumps.

Lake water is drawn from Fairmount Reservoir by three turbine driven centrifugal pumps, located in the new Fairmount Pumping Station, and forced to the rising well in the chemical house at the filtration plant. Two of these pumps deliver 75 m.g.d. each, against an 86-foot head, and the third delivers 50 m.g.d. against the same head.

THE FILTRATION PLANT

Baldwin Filtration Plant is located on a fifty acre plot of ground lying between Fairmount Road, on the north, Woodstock Avenue, on the south, East Boulevard on the east, and Baldwin Road on the west. All parts of the plant were designed and constructed to filter 165 m.g.d. which was the maximum capacity of the existing tunnel and intake at Kirtland Pumping Station.

The description of the filter plant may be conveniently divided into the following four subdivisions: the alum storage house; the chemical house and hydraulic jump mixing flume; the coagulation basins and the filters and administration building.

Alum storage house

Due to the location of the filtration plant a considerable distance above and off the line of the nearest railroad, it was impossible to maintain a permanent railroad connection for the delivery of chemicals. This necessitated the construction of an alum storage house at

the nearest railroad siding, and the trucking of alum from this storage house to the smaller storage bins in the chemical house at the filter plant.

The alum storage building is located along a railroad siding, on a plot of ground adjacent to, and just south of, the grounds of the new Fairmount Pumping Station. The building is of reinforced concrete construction faced with brick. It is 86 feet 8 inches by 50 feet 10 inches in plan, with a covered extension over the unloading hopper and railroad siding.

The building is divided into two general floor levels, the one at ground level containing truck runways beneath the storage bins, and the other forming the tops of the bins, upon which are located the screw conveyors for distributing alum.

Alum is delivered to the tracks under the covered extension, to the north of the building in box cars. It is unloaded by a plow operating inside the car, to a counterweighted chute leading from beneath the car door to a hopper, which feeds onto an apron conveyor. The apron conveyor takes the alum a short distance to a roll crusher.

Here it may be crushed and fed onto a bucket conveyor, or by-passed to the bucket conveyor without crushing. The bucket conveyor lifts the alum to the top floor of the building and across to any one of the three screw conveyors running longitudinally of the building over each one of the three rows of storage bins. Each of the screw conveyors discharges into any one of four bins. The total capacity of the twelve storage bins is 1000 tons of alum. The unloading and alum handling equipment was designed to handle alum at the rate of twenty tons per hour.

As alum is needed at the chemical house, a dump body motor truck may be driven under the bin gate at the bottom of the storage hopper and the truck filled with alum. Paved driveways are provided along both sides of the storage building, and openings, closed with steel rolling doors, are provided so the truck may move across the building under any one of four rows of storage bins. The doorways are arranged opposite each other so the truck may enter at one side of the building and leave at the other.

Chemical house and hydraulic jump mixing flume.

The chemical house is located midway along the southerly boundary of the plant. The building is divided into three general floor levels above and one floor level below ground.

The receiving room for alum is located at ground level at the west end of the building. Here a large double door provides entrance for the truck delivering alum. Alum is dumped from the truck through manhole openings in the floor into the storage bins located directly beneath. It may be drawn from the storage bins through a chute located at the bin bottom and controlled by a gate.

Underneath the lowest part of the bins a tunnel has been provided into which the chutes from the bins project. A narrow gauge track runs the length of this tunnel. Mounted upon this track is a narrow gauge flat car, upon which may be placed a circular, bottom dump, alum bucket. When drawing alum, the flat car and bucket are pushed beneath the chute leading from the bin, from which alum is to be drawn. Alum is then drawn through the gate into the bucket. The car with the loaded bucket is then moved along the track, turned on a turntable, and moved into the hoisting shaft.

In the top floor of the chemical house are located the openings into six alum dissolving tanks in which the alum is dissolved by an upward flow of water. Alum is moved from the bottom of the hoisting shaft to the top floor level by means of a motor operated hoist. This hoist is mounted on a carriage traveling on a monorail, suspended from the lower chord of the roof trusses. This monorail leads from the hoisting well to a position over each one of the dissolving tanks, so the alum in the bottom dump bucket may be discharged directly into the dissolving tanks.

The alum solution flows directly from the dissolving tanks to solution tanks located just east of them. There are four solution tanks. The dissolving and solution tanks are arranged in two groups, one group on either side of the center of the building and the tanks in each group are interconnected so that alum solution from any one of three dissolving tanks may be discharged into either one of two solution tanks. On the next floor below are located the orifice boxes for controlling the rate of flow of alum solution. Gravity flow of the alum solution is obtained from the dissolving tanks through the solution tanks and orifice boxes to the point of application to the water in the rising well.

The water to be filtered is discharged from the two 60-inch mains leading from the low lift pumps at the pumping station into the rising well, which is ten feet wide and extends across the entire width of the chemical house. From the rising well the flow is through a wide shallow channel to the entrance of each of the three parallel

hydraulic jump mixing flumes. These take the place of the usual baffled mixing channel.

From the mixing flume the water passes through two sets of over and under baffles and is delivered at No. 1 Gate House, at the southwest corner of the coagulation basins.

Coagulation basins

The four coagulation basins are located lengthwise along the east end of the filtered water reservoir. Across the south end of the basins, and running parallel to Woodstock Avenue, is the influent conduit with gate houses numbered one to three inclusive, controlling the flow of water into the different basins.

Along the north end of the basins is the effluent conduit with gate houses, numbered four to six inclusive, controlling the flow of water out of the basins. Along the west side of the basins and between them and the reservoir is located a conduit connecting gate houses one and six. By the proper manipulation of sluice gates, the entire flow of water may be bypassed around the coagulation basins and through this conduit.

The water is introduced into each basin over a submerged weir extending the full width of the basin and is drawn off over a similar weir at the other end of the basin.

Each basin is provided with a longitudinal drain running through its center under the floor for almost the full length. Due to the shale foundation upon which the basins are constructed, it was possible to make the floor pitch sharply to this drain, without undermining the wall foundations. This facilitates the removal of sludge, and still keeps the dividing and outside walls of a low height, thus cheapening construction cost as the height of the walls is only about one half of the total depth of the basins.

Each basin is $109\frac{6}{10}$ feet wide and $661\frac{1}{2}$ feet long between influent and effluent weirs, with an area of water surface of about seventy three thousand square feet and volume of eight million two hundred thousand gallons. The maximum water depth is $18\frac{1}{2}$ feet, with a minimum of $9\frac{8}{10}$ feet. and an average of $14\frac{9}{10}$ feet.

At full capacity of the plant the velocity of flow is $2\frac{36}{100}$ feet per minute, with a detention period of four hours and forty minutes.

Filters and Administration Building

The forty rapid sand filters are located along the north side of the reservoir. They are arranged symmetrically about a large well lighted central pipe gallery, the cover of which forms the floor of the operating gallery, which is at the same level as the tops of the filter tanks. At the center, the administration building divides this long double row of filters into two sections.

The operating gallery is covered by a high roof supported on walls vertically above the front line of the filters and bearing on concrete beams forming a part of the roof covering over the filters. The roof over the filters is of concrete, and of sufficient height to provide ample clearance for walking upon the inspection walks over the tops of the filter tanks. These walks are at the same level as the operating gallery floor and provide ready means for observing washing of all parts of the filter surface.

Each filter is $33\frac{1}{2}$ by 49 feet inside measurements in plan, with an area of sand surface of 1450 square feet. The depth from the concrete floor of a filter to the top of the observation walks is $13\frac{1}{2}$ feet.

The strainer system placed on the floor of the filters is of the perforated pipe lateral and manifold type. The laterals are of cast iron, $2\frac{1}{2}$ inches in diameter and spaced 7 inches apart. They are drilled on their underside with $\frac{11}{32}$-inch diameter holes, spaced about $4\frac{1}{4}$ inches apart.

Each filter contains twenty two inches of graded gravel, placed in four layers and ranging from $1\frac{1}{2}$ inches to $\frac{1}{16}$ inch in size. On top of the gravel is 30 inches of sand, having an effective size of 0.38 of a millimeter.

The settled water flows from Gate House No. 6 to the administration building through a concrete conduit along the outside wall of the northeast effluent gallery. At the administration building the conduit makes a right angle turn and runs through it to a junction with the concrete distributing conduit running through the length of the pipe gallery. Cast iron pipe and fittings connect the filters with the concrete conduit.

Directly under the filters are located small filtered water reservoirs, which receive the discharge from the filter effluent lines. Each one of these effluent galleries is connected by a 54-inch pipe line with a central concrete filtered water conduit in the lower part of the administration building. This filtered water conduit terminates in a

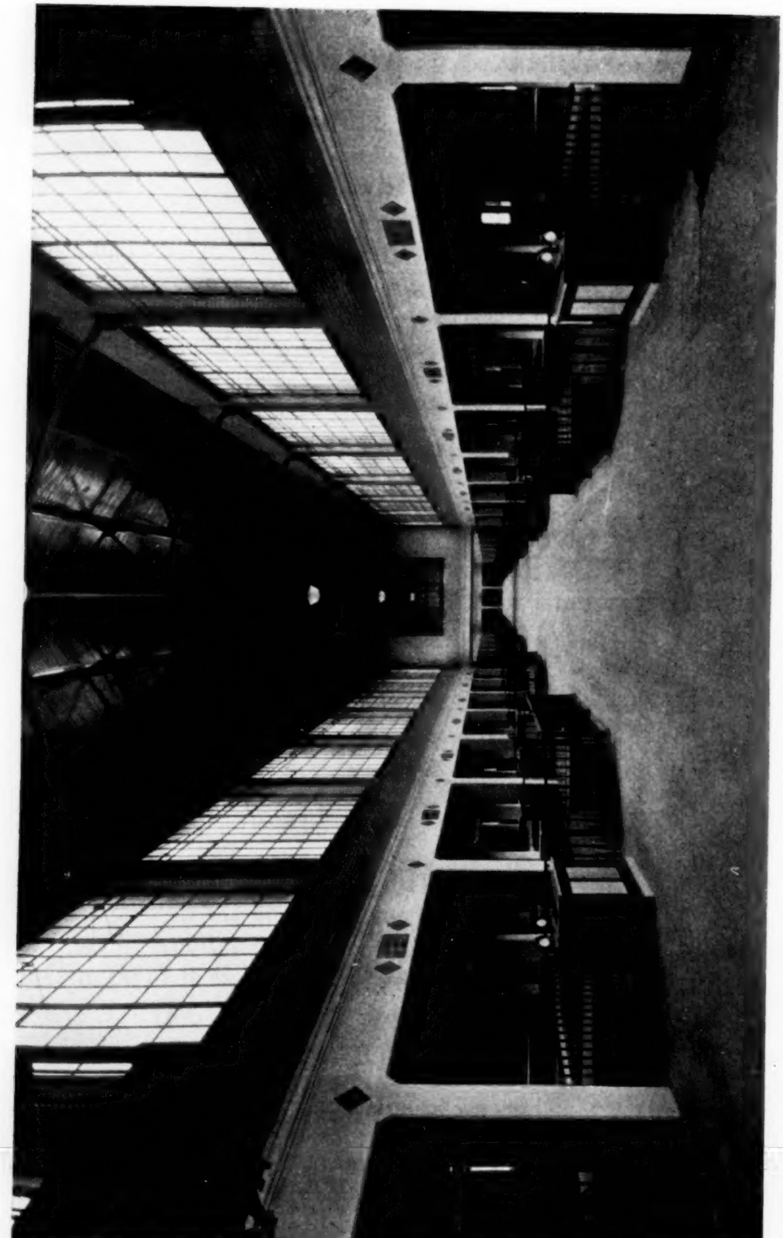

Fig. 1. West Operating Gallery, Baldwin Filtration Plant

forebay near the north wall of the reservoir, with sluice gates to control its discharge into either half of the reservoir.

All the filter valves, except the filtered water waste, are hydraulically operated and controlled from the bronze and marble operating tables, mounted on the floor of the operating gallery, at each filter.

Wash water is stored in two steel tanks, each 60 feet in diameter and 12 feet deep, located on the top floor of the administration building. The storage capacity of the two tanks, with 10 foot depth of water, is 423,000 gallons.

A common supply and discharge riser connects the two tanks with the wash water main in the pipe gallery, at a cross in the lower part of the administration building. The discharge pipe from the wash water pumps is also connected at this cross.

At the extreme west end of the wash water main in the west pipe gallery, connection is made with a 24-inch distribution main carrying water from the first high service reservoir. Thus two ways are available for filling the wash water tanks, by using water from this emergency connection, or by pumping from the special wash water pumps.

Four electrically operated wash water pumps, having a total capacity of fifteen million gallons daily, are located in a pump room adjacent to the lowest floor of the administration building. These pumps obtain their suction from either one of the two north effluent galleries.

Each one of the pumps is operated by a separate float in the wash water tanks.

Filtered water reservoir

The filtered water reservoir has a storage capacity of 135,800,000 gallons, and is the largest covered reservoir in the world. It is 1008 by 521 feet inside dimensions in plan, with a maximum water depth from lowest point of floor to overflow, of 36 feet. A dividing wall, parallel to the short dimension and located at the center of the long side, divides it into two basins, each about 500 feet square. The reservoir is constructed of concrete, with a concrete groined arch roof, supported by 1196 columns 30 inches in diameter, 34 feet, 3 inches high, and spaced 20 feet $3\frac{1}{2}$ inches on centers.

Filtered water is discharged into the reservoir by means of a channel inside the reservoir, running practically the entire length of the north wall. At regular intervals along the side of this channel, weirs permit the overflow of water from the channel into the reservoir.

Water is collected for discharge from the reservoir by ports located near the floor level along the entire length of the south side. These ports lead to a conduit within the south wall, which connects with a conduit in the west wall, leading to Gate House No. 7. At this gate house double sets of valves control the flow of water to the distribution system.

This reservoir, in addition to being the clear well for the filter plant, also serves as a supply reservoir floating on the low service district.

SUPPLY OF FILTERED WATER TO THE DISTRIBUTION SYSTEM

Leading from Gate House No. 7 are seven mains. Two mains, 36 inches in diameter, and three, 48 inches in diameter, supply water to the low service district, and two, 48 inches in diameter, furnish water to the suction header of the first and second high service pumps at the new Fairmount Pumping Station.

In addition to the low lift pumps already mentioned, Fairmount Station contains the following turbine driven centrifugal pumps: two pumps to deliver water to the first high service reservoir, each one with a capacity of 20 m.g.d. against a 135 foot head. Three pumps to deliver water to the second high service reservoir, two with a capacity of 15 m.g.d. each and a third with a capacity of 20 m.g.d all against a 400 foot head. Each one of these two 15 m.g.d. pumps may be changed to 20 m.g.d. capacity by changing the runner in the turbine, thus giving an ultimate total second high service pumping capacity of 60 m.g.d.

Steam for operating these turbines is supplied at a pressure of 300 pounds at the throttle by four 1,000 H.P. Stirling boilers. Steam is bled from some of the turbines at 125 pounds pressure for supplying the municipal heating system.

The total cost of the filter plant alone exclusive of land and final landscaping, was $5,908,000.00, and of the reservoir $2,900,000.00, making a total of $8,808,000.00.

WATER TREATING PROBLEMS IN RAILROAD PRACTICE[1]

By S. C. Johnson[2]

The water treating problems encountered in railroad practice vary to some extent from those usually given consideration in municipal service. The bacteriological feature is generally considered of minor importance and the question of turbidity is subordinated to the influence of the scale forming or corrosive salts.

Although water supply is one of the prime essentials in the operation of a steam railroad, it is of interest to know that the details and problems, especially with regard to quality, were formerly given but minor consideration. In the building of railroads, the major interest was expended in the construction of the roadbed and the operation of trains. Nothing was said of water supply, if it was adequate and not too muddy and water stations were installed where necessity and expediency demanded. These facilities consisted merely of some means of supplying water to the engine tank for steam consumption. However, with the alleviation of construction problems, conditions changed and greater attention to possible economies has become necessary under the strict regulations which now govern the operation and financing of our railway properties.

The quality of the water supply is closely associated with the operating efficiency of a railroad and its result has a marked influence on the locomotive maintenance expense. Only recently two prominent railroads have undertaken the reorganization of their water supply department and instigated treatment based primarily on the remarkable savings made by such refinements on adjacent first class railroads.

Of the 350 billion gallons of water now being used annually for steam purposes on American railroads, it is estimated that 50 billion, or about 15 per cent are receiving treatment in some form. At a general average cost of 4 cents per 1000 gallons for treatment,

[1] Presented before the Boiler Feed Water Studies Committee Session, Buffalo Convention, June 9, 1926.

[2] Chief Chemist, Water Supply Department, Chesapeake and Ohio Railway, Huntington, W. Va.

the yearly operation expense is in the neighborhood of $2,000,000. There are approximately 1200 water stations out of a total of 16,000, where chemicals are added and the total investment in softening plants, including the inexpensive as well as the elaborate types, is at least $10,000,000. It is estimated that these plants are removing 100,000,000 pounds of scale forming solids annually, which, if allowed to enter the locomotive boilers, would represent an additional expense in locomotive operation and maintenance of approximately $13,000,000.

There has been no detailed general survey made to show the sources of railway water supply. However, in Water Supply Paper 496, of the United States Geological Survey, a classification of 307 water supplies from the principal cities of the United States indicates that 234 were obtained from surface waters and 73 from wells. This ratio will probably hold true to a large extent in railroad service.

The properties in water which cause trouble in stationary power plants are of similar concern in locomotive practice, although the refinements are not, as yet, applicable. The chief concern seems to be the non-carbonate scale which causes damage by forming hard cement-like coating on the heating surfaces with consequent deterioration of the material and fuel loss. The carbonates of calcium and magnesium are troublesome when present in large quantity, due either to increasing the bulk of the scale or precipitate. Waters containing mineral acids or with low pH values are occasionally encountered which initiate pitting and corrosion troubles if not corrected. In some parts of the country, particularly that section commonly known as the alkali plains, it is necessary to use waters high in alkali salts, principally sodium sulphate, which not only aggravates the foaming tendency of the waters, but also contributes to an electrolytic condition which accentuates pitting and corrosion unless counteracted. It is possible that siliceous matter has entered into the scale problems in some quarters, but the complaints from this possibility have been of minor importance and it is only within a recent period that serious consideration has been given to the elimination of mud and suspended matter.

The development of water treatment on American railroads has received its greatest attention on middle western systems where the objectionable quality of the natural waters was such that some form of treatment early became an operating necessity. Possibly, because of practicability, or lack of research work or information on this

subject, efforts toward correction were confined at first to internal treatment, principally with so called "boiler compounds" or "metal treatment" with secret formulae. Where conscientious attention was given the troubles were somewhat alleviated, especially with waters of the more moderate hardness, but unscrupulous competition developed with "mystery" products of but little value which cast serious reflection on this method in many quarters. It was therefore found advisable by many railroads to find some more thorough and systematic means of handling, although internal treatment with compounds, applied either directly to the locomotive or in wayside tanks, is still giving good service where they are being handled under intelligent and careful supervision.

The next development in counteracting the harmful impurities was in the application of soda ash, both direct in the boiler or at wayside tanks. The scale reduction properties of this material are well known and this appears to be the least expensive systematic treatment from a first cost standpoint. However, the precipitate formed by this reaction is so finely divided that the sludge in the boilers, together with the increase in alkali salt concentration, causes serious foaming conditions and the system has been found objectionable unless followed up with careful supervision to insure the boilers being blown down sufficiently to maintain the concentration within workable limits.

The systematic treatment with soda ash at wayside tanks appears first to have been developed on the C. B. & Q. R. R. and later extended to the Wabash, Frisco and the Alton. Several other roads are using it to some extent. The method consists in treating all waters, where necessary, to insure an excess of about two grains per gallon sodium carbonate. Frequent check is made of samples from locomotive boilers and effort is made to maintain approximately 15 per cent of the total dissolved solids as sodium carbonate. This internal inspection is also necessary to insure sufficiently frequent blowing to keep the total dissolved solids below 125 grains per gallon in order to prevent foaming delays. Where sufficient supervision is provided to insure the carrying out of the predetermined practice, very satisfactory results have been secured. However, the necessity for the careful check and follow-up of the locomotive operation presents such difficulties that the extension of this system has been somewhat limited.

Experiments with zeolite softening for railway service have not

been altogether satisfactory, although tests being made at the present time on the western coast indicate possible success with certain types of waters. The preponderance of surface supplies, with their occasional high content of suspended matter, limit the scope of this system as well as the dissolved solids quality, unless prefiltration is provided, with additional expense for installation and maintenance.

The standard and usual method of complete railway water softening now practiced consists in the addition of lime and soda ash to the water in predetermined amounts at wayside settling tanks. Its object is not only to soften the water, but also to remove the precipitated sludge with mud or suspended matter, so as to deliver the waters to the boilers not only soft but clean.

The lime and soda process of treatment in railway service has developed from the simple intermittent system which consisted merely of two or more tanks which were filled, treated and used alternately, through the intricate proportioning devices with continuous automatic proportioning, back to the more sensible and simple continuous systems. The chief essentials are proper chemical proportioning and sufficient mixing and reaction time followed by sedimentation and clarification before delivery of water for use.

Many intermittent systems are still in use and the capacity of treating tanks varies from 10,000 to 500,000 gallons, but the governing principle is the same and similar satisfactory results can be secured. The usual means of agitation is by compressed air, which is a more flexible and more easily maintained system than the mechanical agitators which have been tried.

Plants of the continuous type consist of large tanks, usually of steel, with inside tubes of sufficient size to retain the water during the mixing and reaction period of from 30 to 45 minutes. The water and chemicals are mixed in these tubes in continuous proportion, flowing from the mixing tube to the bottom of the sedimentation tank from which they rise to a predetermined point before the clear water is drawn off for service. The specific gravity of the precipitated sludge is sufficiently greater than water to permit complete clarification in five hours, if the vertical velocity of the settling water does not exceed 8 feet per hour, provided, of course, that the proper amount of chemicals have been added to insure complete reaction and unbalanced equilibrium avoided. If clarification troubles are experienced, filters are sometimes provided which usually consist of matted

excelsior at the top of the sedimentation tank, although there are a number of plants in service with gravity or pressure sand filters. Some experimenting is again being done with the elimination of the downtake tube and merely running the chemicals and water together without special mixing or agitation at the bottom of the sedimentation tank, although experience with this system some years ago was not entirely satisfactory.

In any system of water softening for railroads, the largest single factor in securing satisfactory results lies in competent and interested supervision. The chemical quality of the raw and softened water should not only be checked at frequent intervals, but inspection should also be made of the mechanical facilities to insure dependable and uninterrupted service. On railroads where treatment is practiced to any appreciable extent, systematic methods are therefore necessary to permit the situation being handled with minimum force. An outline of the rapid methods for field work and laboratory testing was given on pages 107 to 115 inclusive of the August, 1925, Journal of This Association and these methods are largely a duplicate of those which have been found satisfactory and adopted as standard recommended practice by the American Railway Engineering Association.

The savings which are possible through improvement in quality of railroad water supplies are necessarily dependent upon local conditions In 1914, the American Railway Engineering Association presented figures to show that the cost of each pound of incrusting matter permitted to enter the locomotive boiler, in such condition that it would deposit as scale on the tubes and sheets, was 7 cents, considering only the effect on fuel consumption, boiler and roundhouse repairs and engine time. This figure, transposed to present day prices, is 13 cents. Study by a special committee of the American Railway Engineering Association for the past five years has found that the statistics which have been gathered indicate that this figure is conservative. There is no question but that, with proper treatment of the water, scale and pitting conditions, with their incident boiler maintenance expense, can be largely eliminated and that the fuel consumption in clean and dry boilers is much less than with leaky or badly scaled power. In addition, the large intangible benefits, such as elimination of engine failures on the road and the reduction in delays to traffic and train movements, usually far outweigh the

tangible savings in fuel consumption and boiler repairs. However, each individual case is a problem in itself and requires special study in order to obtain best results.

On the Chesapeake and Ohio Railway, during 1925, there were 30 water softening plants in service at the 207 water stations. Of these 30 plants, 23 were of the continuous type, 2 intermittent, and 5 of the simple soda ash system. Of the 6,135,922,000 gallons of water used for steam purposes, 2,496,038,000 gallons, or 40.7 per cent were, treated and a total of 2,672,080 pounds of injurious scaling and corrosive matter removed before the water was delivered for steam boiler use. The total cost for chemical treatment, including operation, maintenance, interest and depreciation, was $103,715 or an average of 4.5 cents per 1000 gallons, but the cost for chemicals alone only averaged 1.98 cents. The estimated net saving for the year by reason of this treatment amounted to $243,675 which represents 67.2 per cent on the $356,323 amount invested in water treating facilities. This estimated saving averages but $480.00 per locomotive using the treated water, which is a conservative rating.

The wide range of the problem of water treatment, including the design and installation of plants, as well as the individual studies of the water quality and the check of the actual treatment and its effect upon transportation and train movement, well warrants the special study which is being given to it on many roads. In the handling of this problem over the wide range of territory involved on even the smaller railway systems, it is necessary to have the closest coöperation between the chemical supervision and the men actually operating and maintaining the plants, as well as the interest and assistance of the motive power and transportation departments, to secure the best, or even passable, results. The best mechanical facilities will function only in a perfunctory manner or fail entirely, if not followed up by a careful check system, it has been found that an organization with a definitely fixed responsibility is the first essential to successful results from railway water treatment.

MISSOURI HIGHWAY SANITATION PROBLEMS AND PROGRAM[1]

By W. Scott Johnson[2]

The need of proper sanitation along our public highways is developing in importance very rapidly as a result of the more general use of automobiles for transportation and the increase in hard surfaced roads. Supervision of the design and maintenance of public water supplies and sewerage systems has been recognized as necessary by state health departments for some time. The present increasing tendency for our population to move countryward along improved highways automatically imposes city sanitation problems upon rural conditions, and a program having for its purpose supervision of highway sanitation is necessary for reasons similar to those applicable to urban conditions.

It is the purpose of this paper to discuss the problem of highway sanitation in Missouri and the program for supervision which has been initiated by the State Board of Health.

GROWTH OF HIGHWAY TRAFFIC

The extent and importance of the problem of highway sanitation is necessarily closely associated with and in fact dependent upon the density of highway traffic.

The factors governing the growth of highway traffic are, first, number of automobiles in use, and second, the extent and character of highways available. Brief consideration of these two factors indicates several pertinent facts with regard to the growing popularity of travel by automobile and the increase in what might be termed highway population. The ability of the American people to buy automobiles has shown material increase in the last few years. Regardless of the fact that there is today one car to every six or seven persons in this country, recent estimates as high as forty million automobiles, or double the present number, have been prophesied

[1] Presented before the Iowa Section meeting, November 3, 1926.

[2] Chief Sanitary Engineer, State Board of Health, Jefferson City, Mo.

as the future saturation point. In Missouri during the last five years, the number of cars in operation has more than doubled, from 297,000 to 602,000. Available information indicates not only a remarkable increase in automobiles the last few years, but still further increase over the present high figure as cars become more practical and necessary from an economic standpoint.

The extent and character of highways is a factor in highway travel that can be more easily determined in that certain programs and plans are being followed. Last year there was constructed about 30,000 miles of surfaced road in this country. In the past five years 3700 miles of hard surfaced roads have been constructed on the Missouri state system, or six times the previous mileage. The present Missouri highway program calls for the completion of 7640 miles of hard surfaced road, of which 4200 miles are complete. In 1921 automobile travel in this state on hard surfaced roads was practically limited to small areas surrounding the larger cities. Today the state is well started on a program for a complete highway system.

The effect of more automobiles and increasing hard surfaced road mileage has already produced a marked change on travel by automobile. Travel by highway is rapidly developing from a seasonal, uncertain and hazardous adventure into an all year, dependable, and safe means of transportation. The rapidity and extensiveness of this means of transportation have progressed until it ranks among the first, regardless of the fact that it is still in the early stages of development.

Thousands of foreign cars enter Missouri each year especially during the summer months. These out of state travelers spend millions of dollars each year during their visit to this state. Particularly important from the sanitary standpoint is the fact that a large per cent of these tourists spend many days in camps along the highways. Another index of the popularity of highway travel is shown by the total average number of persons which are daily traveling these routes. Considering the improved highways, the State Highway Commission counts show an average of from 1200 to 15000 people daily traveling these roads exclusive of the greater numbers in the immediate vicinity of the larger cities. On the main highways, the population each day equals that of a fair sized city and during the tourist season these lanes of travel are actually becoming the homes of thousands of people day and night.

SANITATION PROBLEM

The growing popularity of highway travel is resulting in a redistribution of population away from the sanitary environment of cities into the open country, where knowledge of sanitation is meager and its practice almost unknown. This large moving population on the highways is restricted to the comparatively limited area of these lanes of travel. This area will seldom exceed the bounds of the highways, tourist camps and towns located along the highways. The length of time spent in Missouri will vary from a few hours in the case of through travelers to many days or weeks in the case of visitors, which have come to take advantage of vacation opportunities offered in many parts of the state.

The history of disease outbreaks and their control has demonstrated that the occurrence of most serious epidemics of diseases have been associated with the movement of people due to political changes or development of new, more rapid and extensive means of transportation. These epidemics of communicable diseases have been most difficult to control and have wrought the greatest distress. The present system of quarantine at ports of entry into this country has been devised as a necessary means of preventing contagious diseases being brought to this country through lanes of travel from foreign countries.

The dangerous possibilities of communicating diseases from place to place by automobile travel is readily apparent when one stops to consider the freedom with which autoists from all parts of the country use the highways for travel and the method of transmission of contagious diseases of the filth-borne type.

The highway tourists today may hail from any place on the North America continent, and represent practically every class of people from hobo to multi-millionaire. They may be coming from localities recently infected by disease and are possibly, unknown to themselves, carriers of diseases. At present no restrictions, such as compulsory registration, medical examination, detention, or other similar check, are placed upon tourists passing from one state into another. In fact, one may frequently pass from one state to another without knowledge of the change. Consequently, there is no way by which the citizens of a state or locality are protected from invasion by tourists who may transmit dangerous diseases.

On the other hand, a tourist is a guest in the state and as mentioned before a most profitable one. Unacquainted with local conditions this stranger may consume water from contaminated sources and contract typhoid fever or other contagious diseases. As a guest and one whom we have good reason to welcome, the tourist should be protected in every way possible against contracting diseases and leave the state or locality a booster and not a knocker.

The spread of diseases of the filth-borne type comes about through the germs being transmitted from sick to well persons by means of food and drink. Carelessness or ignorance in the proper disposal of excreta results in the germs causing typhoid fever, colitis, dysentery, diarrhea and enteritis being washed into unprotected drinking water supplies or carried to food or drink by flies and other insects. As the number of people traveling the restricted area of the highways increases, the dangers from filth-borne diseases increase to a corresponding degree unless sanitary toilets and pure water supplies properly protected from pollution are provided along the highways.

The highway tourist requires water that is cold, clear and pleasant to the taste, giving no thought to its source or possible pollution. The average city inhabitant has become accustomed to safe water supplies and sanitary sewage disposal being provided by a convenient method and without individual responsibility or concern. This promotes a false sense of security with regard to any convenient water supply. Unfortunately, either through thoughtlessness, ignorance or lack of consideration, a large number of people have slight regard for the possible pollution of a water supply for the next person, as long as their own immediate needs have been satisfied. Consequently, the proper sanitation of our highways involves not only safe water supplies and sanitary toilets at convenient intervals along the high ways, but adequate designation and proper maintenance of these, if the permanent citizens of the communities which come in contact with tourists are to be protected and if the tourist is to be protected against contraction of diseases while passing through or visiting a state. It seems opportune that the question of highway sanitation should be inaugurated at this time in Missouri, when the volume of highway traffic is expanding due to the increase in automobiles and the near completion of the highway system. Thus it is hoped to avoid any disastrous epidemics, and provide for proper sanitation before an outbreak of disease has occurred from this source.

PROGRAM FOR MISSOURI

The health protection, comfort and convenience of the highway population should be the aim of an adequate plan of highway sanitation. The problem is statewide in its scope and therefore should come under the jurisdiction of state agencies. The Missouri State Board of Health and the Missouri Highway Commission are co-operating on a plan to establish comfort stations at frequent intervals along the state highways, the same to be indicated by a special highway sign. Many features of this plan are not original. However, it seems well adapted for securing improved highway sanitation in Missouri for the following reasons: safe drinking water supplies are provided along the highways at frequent intervals, protected from contamination; sanitary toilets conveniently located are provided; permanent, conspicuous and standard markings indicate comfort stations; comfort stations are owned and operated largely by private individuals, who are vitally interested in their proper upkeep; the program is not negative in character, since it is the satisfactory comfort station which receives the approval. This feature simplifies the supervision and gives a service of a positive nature to the highway travelers that meets with greater approval than one of prohibition.

In order that the comfort stations be properly equipped in a sanitary manner with a view to the convenience of the autoists as well as the sanitation of the highways, the following specifications have been formulated.

GRADE A COMFORT STATION

Water Supply

1. All grade A comfort stations shall have conveniently available a safe drinking water supply free from sanitary defects and conforming to the standards of the United States Public Health Service.
2. Individual paper drinking cups shall be provided.
3. No common drinking cup or glass shall be permitted.

Toilets

1. Two toilet rooms shall be provided, separate for men and women.
2. A minimum of one each of the following plumbing fixtures shall be provided for each toilet:

a. Water closet bowl with impervious seat and closet tank.

b. White enamel wash basins; an improved liquid or powdered soap container.

c. Suitable holder for individual or paper towels and receptacle for used towels. No common towel shall be permitted.

3. The sewage shall be disposed of in a sanitary and approved manner.

4. The building and fixtures shall be kept clean and sanitary at all times.

GRADE B COMFORT STATION

Water Supply

1. All Grade B comfort stations shall have conveniently available a safe drinking water supply free from sanitary defects conforming to the standards of the United States Public Health Service.
2. Individual paper drinking cups shall be provided.
3. No common drinking cup or glass shall be permitted.

Toilets

1. Two indoor toilet rooms shall be provided, separate for men and women.
2. A minimum of one chemical toilet shall be provided for each toilet room.
3. A wash basin, supply of water, an approved liquid or powdered soap container, and individual paper towels, shall be provided.
4. The building and fixtures shall be kept clean and sanitary at all times

GRADE C COMFORT STATION

Water Supply

1. All Grade C comfort stations shall have conveniently available a safe drinking water supply free from sanitary defects and conforming to the standards of the United States Public Health Service.
2. No common drinking cup or glass shall be permitted.

Toilets

1. Two sanitary pit, or other approved type, outdoor toilets shall be provided, separate for men and women.
2. These shall be constructed, maintained and operated in accordance with the principles outlined in bulletin No. 20, State Board of Health of Missouri.

For the present these three grades of comfort stations have been established in order that safe facilities can be provided that are consistent with the amount of traffic and local conditions. While grade A stations are being urged wherever possible and will be practically the only type along the more important routes, there will be for the present a large number of B and C type along less important highways.

The Division of Sanitary Engineering of the State Board of Health has made a field survey of all places along the National highways in Missouri that are interested in complying with these specifications and are adaptable by location for this purpose. The survey of the water supply upon which approval is based takes into consideration the location as regards possible sources of pollution; the construction

of well or cistern, including type and condition of walls or casing, design and condition of pump, surface protection and other features which influence the safety of the water supply; and bacteriological examination of a sample. The requirements are explained and instructions left covering the improvements necessary. Samples are collected for bacterial analysis only from those water supplies which upon careful field survey prove properly protected.

After completion of the necessary improvements, as outlined at the time of the survey, application is made on a standard blank to the State Board of Health for reinspection. If upon reinspection the comfort station meets the State Board of Health requirements, the Highway Department is notified and a standard sign is placed upon the right of way, indicating the approval of the comfort station. In addition a certificate of approval is issued to the comfort station indicating that the conditions meet the State Board of Health specifications for an approved comfort station, and the grade of same. Several inspections will be made each year of the approved comfort stations, including periodic bacterial examination of the water supply. The possession of the highway sign and the annual renewal of the certificate of approval will be dependent upon the result of these inspections.

Standard signs will also be used at city limits to inform the tourist with regard to the safety of the city water supply where such supplies exist. Every city and town on a highway with a municipal water supply will wish to receive the approved water signs. The majority of these supplies are safe and those which need improvements will be given every opportunity and aid in bringing their supply up to the standard. The program also includes a survey of city tourist camps and recommendations for changes necessary to meet the specifications for an approved highway rest station.

The signs to be used to indicate approved comfort stations and safe water supplies are similar to the national highway signs in that they are standard for use on all national highways traversing the United States. Therefore, the autoist will soon become acquainted with these signs and will know the advantages offered regardless of the particular locality.

PROGRESS OF WORK

The increase in highway traffic has been an incentive to the establishment of business places catering to the needs of the automobilist. These establishments for the most part consist of filling stations,

garages, tourist camps and stores where food can be obtained. These private concerns have shown exceptional interest in the program for highway comfort stations and a large number have already started or completed improvements to comply with the specifications of the State Board of Health for a sanitary comfort station.

During the past seven months one man's entire time was spent covering the 2750 miles of national highways supervising this program. During this period 591 inspections were made of 325 comfort stations. Reinspections have been made of 209 of these stations one or more times.

Of the water supplies for these comfort stations 231 come from privately owned wells or cisterns and 102 from municipal water systems. Of the privately owned water supplies 90 or 39 per cent have been improved to meet the specifications. Water supplies from municipal owned sources were satisfactory except in 4 instances. The total number of satisfactory water supplies available at comfort station is 188.

Sanitary toilet facilities are provided for by privies at 202 comfort stations, by city sewers at 55, by septic tanks at 62 and by chemical toilets at 21. A total of 81 comfort stations have improved toilet facilities to meet the specification, which in addition to those already satisfactory brings the total number of comfort stations with sanitary toilets to 198. Complete improvements, including safe water supply, sanitary toilets and necessary equipment, have been secured at 39 comfort stations or 12 per cent of the stations inspected. These places have received certificates and have been approved for the highway sign. Many comfort stations, as indicated above, have made decided improvements, but could not be approved because of failure to meet the requirements in a few details. The necessity for strict compliance with the specifications has been emphasized and this has doubtless resulted in fewer but more satisfactory comfort stations.

The present program for highway sanitation in Missouri is comparatively new. The work has received public approval, however, to a marked degree. By providing sanitary toilets and safe drinking water supplies along the highways, the dual purpose of highway sanitation, namely, the protection of permanent residents and the traveling public, will be to a large degree accomplished. This new phase of sanitary engineering does not offer an immediate method for evaluation. However, as a result of these sanitary improvements, the future holds prospects for an appreciable reduction in vacation typhoid and other filth-borne diseases which have recently shown

considerable increase. In addition to better health protection of our highway population, considerable value of an educational nature will result from this work in the rural communities. Obviously a general program for sanitation of rural communities, although greatly needed, would require a considerable increase in personnel of the present state board of health. The establishment of safe water supplies and sanitary toilets at comfort stations will constitute a constant demonstration in sanitation to the surrounding community and unquestionably an influence for better conditions in general.

A highway system provided with well marked and located rest stations will not only afford proper sanitation and health protection for the rapidly growing population traveling our highways, but a convenience that will aid materially the comfort and pleasure of the autoist and one that the general public understands and appreciates.

SUMMARY

The increase of highway traffic in Missouri, resulting from the use of more automobiles and progress made toward completion of the hard surfaced road program, is rapidly creating a sanitary condition which demands attention for public health reasons. The large population, from widely scattered localities, traveling the highways during the day and sleeping in tourist camps at night, is dependent upon the drinking water and comfort station facilities afforded by the highways. Opportunities for the spread of infection are manifold unless proper supervision of water supplies and sanitation of environment of the highways is maintained. This is a highway problem and necessarily, therefore, statewide. It should for this reason come under control of the State Board of Health. In Missouri a program of co-operation between the State Board of Health and the State Highway Commission has been initiated whereby comfort stations are established under private or municipal ownership along the highways. These, if maintained according to State Board of Health specifications, receive a special highway marker placed and maintained by the State Highway Commission and a written certificate of approval from the State Board of Health. The many improvements secured as a result of one season's work indicates that this program has thus far been received favorably by the traveling public and owners of establishments who are interested in providing comfort stations.

The development of this program should offer a solution to the most important highway sanitation problems and greatly enhances the convenience and pleasure of highway travel.

CHLORINATION FOR ALGAE CONTROL

By Chester Cohen[1]

The control of taste and odor has been one of the chief difficulties experienced in supplying a palatable water in Texas during 1926. Some 117 towns are using surface water for domestic purposes, and in a majority of cases an impounding reservoir or lake is used for storage purposes. These surface reservoirs occupy on an average an area of perhaps seventy acres, with an average depth of not more than ten feet. A great proportion of our surface water contains a large amount of bicarbonate alkalinity. This characteristic, together with the long periods of sunlight and fairly high temperatures, creates extremely favorable conditions for algae multiplication. The density of plankton life in these reservoirs is relatively high, due to the limited volume of water coming in from water sheds of small area, and the depth of penetration of the sunlight through the relatively clear waters. This is productive of heavy growths of plankton and subsequent production of objectionable tastes and odors. The surface waters of the state support a large number of the typical plankton forms, among which oscillaria, spyrogyra and navicula are the forms most commonly occurring from the three main algae divisions. The general preparatory training of the ordinary plant operator in Texas does not include microscopical work and usually the first indication that he may have of a large increase in the plankton life is an increased color in the water or complaints of taste and odor from the consumers.

In such cases the usual copper sulphate remedy is applied, calculations being made from the standard dosage table as compiled by investigators some years ago. The treatment is applied either by dusting the crystal lightly over the water surface, by solution feed, or by dragging a sack of the chemical through the water at the end of a boat. Here, as in other states, this method has given satisfactory results where properly and sufficiently frequently applied. For large bodies of water the Texas State Board of Health has felt justified because of its experience, in continuing to recommend copper sulphate treatment.

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ALGAE TROUBLES IN SMALL RESERVOIRS

There are a number of surface or combined surface and well supplies which do not use large impounding reservoirs. Such systems rely, for storage, upon a series of large concrete or earthen basins holding from one to ten million gallons of water. These basins are designed to provide temporary storage of one or more days' supply to serve in the event of a plant breakdown or necessity of machinery repair. A constant flow passes in and out of these tanks. Short circuits occur and the period of retention is subject to considerable variation. Some of these collection or storage basins, especially where well water constitutes the bulk of the supply, provide a retention period of only a few hours. Such well supplies, of which there are a large number in Texas, have a bicarbonate alkalinity content of 200 parts per million, or more. Being exposed to the sunlight and favorable temperature conditions, they often support a considerable algae growth. It has been difficult to keep the side walls of the storage tanks free of algae. The seeding of these tanks from the incoming water and from the air, together with the organisms that develop in the stagnant corners and dead areas, impregnates the remainder of the system and subsequent growths are especially noticeable in the sedimentation and coagulation basins where there is a high concentration of free carbon dioxide gas. Finally the whole plant including the filter beds may be affected. The advisability of covering these basins has often been discussed. The large surface area, the considerable expense, and the necessity of having the basin readily accessible for cleaning has resulted in this remedy being considered in most instances impractical. It has previously been the custom to drain and clear these tanks at such intervals as necessary—sometimes as often as every three or four days. The floors and walls are swabbed with a strong copper sulphate solution and then the basin is flushed and refilled with a fresh supply. The costs of the wasted water and the extra pumpage involved, of labor for this operation and of chemicals used, and the fact that the reservoirs are out of service over this considerable period of time make this method of control unsatisfactory. Furthermore, our attention has been directed to certain data and experiments by chemists and engineers which seem to indicate that previous ideas concerning the action of copper sulphate in water might be erroneous. Some of these data show that copper salts do not necessarily precipitate as hydroxide, but remain

in solution and so are passed on to the consumer—a questionable practice if we are to regard copper as a cumulative poison. This fact, if true, becomes of especial importance because of the short storage period which these particular types of surface supplies receive. Because of the possibility of incomplete precipitation of the copper, and still further because of the uneconomical procedure involved in copper sulphate treatment of these small retention basins, the Texas State Board of Health undertook an investigation of the possibility of using some other medium as an efficient and economical algicide.

EXPERIMENTS AT MEXIA, TEXAS

The first observation and experimental work was begun at Mexia, Texas during the spring months of 1926. The water here consisted of a combined limestone spring and deep well supply. The spring supply is pumped directly from the spring collecting basin and the well supply from an open earthen collecting basin of 40,000 cubic feet in area at the wells. The two supplies mix in a large concrete settling basin of approximately six million gallons capacity located in the city. Seeding of algae undoubtedly took place in all three of these open basins. Unusually high densities of oscillaria and protococcus forms were generally found in the concrete service reservoir. Stagnant areas of this reservoir provided seeding beds for the algae and in several instances the water turned a decidedly green color within a few days, at the same time exhibiting a strong fishy and disagreeable odor. Inasmuch as the two most common methods of control, i.e., copper sulphate as an algicide, or covering of the reservoir, were impractical at this point, it was necessary to employ a different type of algicide or else attempt to inhibit algae development through the elimination of potential food supplies. Accordingly, laboratory experiments were conducted with these different waters and included both of the above methods. Table 1 indicates the results obtained.

From table 1 it seems reasonable to conclude that the lime treatment of this supply for the purpose of efficiently softening it would have resulted in a considerable reduction of the algae growth. This reduction in algae concentration was, of course, to be expected inasmuch as the the necessary food supply was removed, thus preventing the continuation of the life process of the organisms. Further experiments together with observation and data from other Texas plants substantiated the correctness of the above results. It must be

borne in mind, however, that complete softening is not always practicable due to the particular layout of a plant not originally designed

TABLE 1
Lime treatment

	SAMPLE TREATED FOR	SOURCE	RESULT
a	CO_2 removal	Well	Algae growth not inhibited
b	CO_2 removal	Spring	Algae growth not inhibited
c	CO_2 removal	Spring	Algae growth not inhibited
d	CO_2 removal	Mixed	Algae growth not inhibited
e	CO_2 removal	Mixed	Algae growth not inhibited
f	Partial softening	Well	Algae growth not inhibited
g	85 per cent softening	Well	Algae growth inhibited
h	85 per cent softening	Well	Algae growth inhibited
i	85 per cent softening	Well	Algae growth inhibited
j	85 per cent softening	Well	Algae growth inhibited
k	85 per cent softening	Spring	Algae growth inhibited
l	85 per cent softening	Spring	Algae growth inhibited
m	85 per cent softening	Well	Algae growth inhibited
n	85 per cent softening	Mixed	Algae growth inhibited

TABLE 2
Chlorine dosage

NUMBER OF SAMPLES	SOURCE	CHLORINE DOSAGE	EFFECT ON ALGAE
		p.p.m.	
3	Spring	0.25	Algae development partly inhibited
2	Well	0.25	Algae development not inhibited
3	Mixed	0.25	Algae development not inhibited
1	Well	0.5	Algae development not inhibited
2	Well	1.0	Algae development not inhibited
2	Spring	1.0	Algae development inhibited
4	Mixed	1.0	Algae development almost inhibited
1	Spring	1.5	Algae development inhibited
1	Well	2.0	Algae development inhibited
1	Spring	3.0	Algae development inhibited
2	Mixed	3.0	Algae development inhibited
1	Well	4.0	Algae development inhibited

to serve as a softening plant. The construction of additional necessary treatment units at that time, with the necessity of changing the type of operation and of employing more skilled water plant

operators was not considered advisable. At this particular place, lime softening, although economically advisable, would not have proved practicable as an immediate corrective measure.

TABLE 3

Dissipation of chlorine

CHLORINE DOSAGE	RESIDUAL CHLORINE AFTER			EFFECT OBSERVED 6 DAYS AFTER TREATMENT
	24 hours	48 hours	72 hours	
p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	
0.1	0.05	0.0	0.0	D and L
0.1	0.05	0.0	0.0	D and L
0.4	0.30	0.2	0.0	D
0.5	0.2	0.01	0.0	D
0.5	0.1	0.01	0.0	D and L
0.5	0.3	0.05	0.0	D
0.6	0.3	0.05	0.0	D
0.8	0.4	0.1	0.05	D

D = dead organisms; L = living organisms.

TABLE 4

Dissipation of chlorine

CHLORINE DOSAGE	RESIDUAL CHLORINE AFTER			EFFECT OBSERVED 6 DAYS AFTER TREATMENT
	1 day	2 days	3 days	
p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	
0.2	0.1	0.0	0.0	
0.3	0.1	0.0	0.0	
0.4	0.2	0.05	0.0	
0.4	0.2	0.05	0.0	
0.5	0.2	0.05	0.0	D
0.75	0.2	0.05	0.0	D
1.3	0.2	0.05	0.0	D
1.5	0.2	0.05	0.0	D
1.5	0.2	0.05	0.0	D
1.5	0.2	0.05	0.0	D
1.8	0.3	0.05	0.0	D
2.2	0.4	0.05	0.0	D

D = dead organisms.

CHLORINATION EXPERIMENTS

Experiments with the use of chlorine as an algicide were then begun. In this work it was realized that, if chlorine gas should prove

efficient, a considerable saving in cost of installation and operation would result. The plant was already applying chlorine for the purpose of bacteria removal. The first experiments with chlorine were conducted in the laboratory in order to secure information as to the quantity of chlorine required to effect algae destruction. The effect secured in the preliminary tests is shown in table 2.

From the results of this experiment we felt inclined to believe that chlorine could be used to practical advantage in algae control. Further experiments undertaken in the laboratory are tabulated in tables 3 and 4.

As a result of these experiments chlorination of the water was begun at each of the sources already described, namely, the spring and the well reservoir. This dosage was applied at the rate of about one part per million. As long as it was continued it consistently succeeded in preventing a recurrence of the heavy algae growth. However, complete freedom from algae forms was not attained, probably due to constant reseeding from the spring supply and possibly also air contamination. A temporary breakdown of the chlorine machines with a consequent reduction of the dosage resulted in an unusually heavy regrowth of algae.

EXPERIMENTS AT LUFKIN, TEXAS

The degree of success obtained at Mexia determined the investigators to follow the same procedure at Lufkin, Texas some months later. Here the installation consisted of a series of four open round concrete tanks about 50 feet in diameter. The supply is obtained from a deep well, the water from which is high in iron content and bicarbonate alkalinity. After nozzle aeration and passage through a coke bed (fig. 1) the water passes through the settling tanks in series and is then pumped into the distribution system. Chlorine is applied at the pump suction line for bacterial control. These tanks hold about 200,000 gallons each. The total daily pumpage averages 500,000 gallons. This means that about one day's retention period is provided in these tanks for the purpose of settling out the suspended iron. The operation of this system is hampered during the summer months due to heavy growths of spirogyra developing in the tanks within a period of a few days. This growth would become so heavy and thick that it necessitated regular weekly emptying and cleaning of the tanks. The operation data for the plant indicated that the water wasted during the cleaning of the tanks cost $13.50 per month

and the additional pumpage and labor involved cost $30.00 per month, This, together with the cost of the chemicals used, the wash water

FIG. 1. AERATOR AND COKE FILTER AT LUFKIN, TEXAS

FIG. 2. TYPICAL SMALL EARTHEN RESERVOIR IN TEXAS

for flushing the tanks and other incidentals, made a monthly item of $88.50 for algae control at this plant.

Based upon the favorable results in the Mexia experiment, the investigators decided to combine the chlorination for bacterial

purposes and that for algae control into one treatment and to apply the chlorine at the inlet to tank 1, i.e., by prechlorination. The chlorine treatment was increased to 1.1 p.p.m., which represented a 50 per cent increase over the previous doses applied to the settled water for bacterial removal alone. The cost of this increased chlorine

TABLE 5

Data on treatment of water containing oscillaria and diatoms

(750 standard units per cubic centimeter)

SAMPLE	TREATMENT	DOSAGE	EFFECT OBSERVED (DAYS FOLLOWING CHLORINE APPLICATION)		
			3	5	8
a	Chlorine	0.05 p.p.m. residual	D	D	D and L
b	Chlorine	0.50 p.p.m. residual	D	D	D and L
c	Lime	CO_2 neutralized	D	D	D
d	Lime	Bicarbonate (neutralized)	D	D	D
e	None		L	D and L	D and L

D = dead organisms; L = living organisms.
Chlorine samples later became reseeded from the air.

TABLE 6

Data on treatment of water for algae control

SAMPLE	TREATMENT	DOSAGE P.P.M. RESIDUAL	EFFECT OBSERVED (5 DAYS AFTER CHLORINE APPLICATION)
a	None	0	L
b	Chlorine	Demand only	D and L
c	Chlorine	0.25	D
d	Chlorine	0.50	D
e	Chlorine	0.75	D
f	Chlorine	1.0	D
g	Chlorine	2.0	D
h	Chlorine	3.0	D
i	Chlorine	5.0	D

dosage amounts to $6.00 per month against the former figure of $88.50 per month for washing out the tanks and treatment with copper sulphate. This method of chlorine treatment has now been in operation at the Lufkin plant for a period of seven months or more and in that time it has not once been necessary to clean the tanks. The

TABLE 7

Effect of chlorine on spirogyra

Sample	Treatment	Chlorine dosage	Effect observed (contact period in hours) 1: Residual chlorine	1: Algae	3: Residual chlorine	3: Algae	6: Residual chlorine	6: Algae	12: Residual chlorine	12: Algae
		p.p.m.	*p.p.m.*		*p.p.m.*		*p.p.m.*		*p.p.m,*	
a	None		0	L	0	L	0	L	0	L
b	Chlorine	0.2	0.05	L	0.04	L	0.01	L	0.01	D and L
c	Chlorine	0.5	0.1	L	0.07	L	0.05	L	0.03	Af and D
d	Chlorine	0.7	0.2	Af	0.1	Af	0.07	A and D	0.05	D
e	Chlorine	0.9	0.2	Af	0.2	Af	0.1	Af and D	0.07	D
f	Chlorine	1.0	0.2	Af	0.2	Af	0.15	D	0.08	D
g	Chlorine	1.2	0.2	Af	0.2	Af and D	0.2	D	0.1	D
h	Chlorine	1.5	0.2	Af	0.2	D	0.25	D	0.15	D
i	Chlorine	2.0	0.2	Af	0.2	D	0.3	D	0.2	D

D = dead organisms; L = live organisms: Af = affected organisms.

TABLE 8

Effect of chlorine on pure culture of oscillaria

Sample	Treatment	Chlorine dosage	Effect observed (30-minute contact with chlorine)
		p.p.m.	
a	None		L
b	Chlorine	Satisfy chlorine demand	L
c	Chlorine	0.1 residual chlorine	L
d	Chlorine	0.2 residual chlorine	L
e	Chlorine	0.3 residual chlorine	L and D
f	Chlorine	0.4 residual chlorine	L and D
g	Chlorine	0.5 residual chlorine	D
h	Chlorine	0.6 residual chlorine	D

Note: After one-half hour, the excess chlorine was neutralized with sodium thiosulphate and a considerable period of time was then necessary before the organisms gave evidence of having been affected. The chlorine appeared to have exerted a feeble inhibitory effect rather than an immediate lethal effect. (See table 9.)

operator informs us that the sides and walls of the basins are always clean and free from algae. The treated effluent is as satisfactory from a bacteriological standpoint as previously, having a total count of less than 20 bacteria (37°C.) and with no indications of B. coli.

Since that time additional laboratory experiments have been carried on in order to determine the action occurring after the chlorine has disappeared, what regrowth of algae might be expected, the exact dosages necessary for various species of algae and the period of con-

TABLE 9

SAMPLE	EFFECT OBSERVED (HOURS AFTER NEUTRALIZING CHLORINE TREATMENT IN TABLE 8)				
	0	6	24	48	72
a	L	L	L	L	L
b	L	L	L	L	L
c	L	L	L	L	L
d	L	L	L and D	L	L
e	L	L	L and D	L	L
f	L	L	L and D	L	L
g	L	L	D	L	L
h	L	L	D	D	D

Note: Evidently some spores or seed had remained alive in sample (G) and developed later.

TABLE 10

SAMPLE	TREATMENT	CHLORINE DOSAGE	EFFECT OBSERVED (TIME OF CONTACT WITH CHLORINE—20 HOURS*)	
			Residual chlorine after 20 hours	Algae
		p.p.m.	*p.p.m.*	
a	None		0.0	L
b	Chlorine	0.1	0.0	L and D
c	Chlorine	0.2	0.01	L and D
d	Chlorine	0.3	0.01	L and D
e	Chlorine	0.4	0.01	L and D
f	Chlorine	0.5	0.03	L and D
g	Chlorine	0.6	0.05	D

* These results were immediately noticeable without having to wait for after effects.

D = dead organisms; L = living organisms.

tact necessary to insure complete killing. Tables 5 to 12 inclusive give some information on these matters.

From tables 5 and 6 it is noted that after five days an algae redevelopment occurs, due to reseeding, to possible spores, or to resistant forms which were not affected by the chlorine treatment. In

table 5 it is interesting to point out further that those samples which were chlorinated are the ones that show evidence of regrowth, whereas the samples in which lime treatment was used do not exhibit this regrowth. The regrowth in the chlorinated samples did not appear, however, until the eighth day following chlorination.

TABLE 11

CHLORINE DOSAGE	EFFECT OBSERVED (PERIOD OF CONTACT)					
	1 hour		6 hours		48 hours	
	Immediately	48 hours later	Immediately	48 hours later	Immediately	48 hours later
p.p.m.						
0.2	L	L	L	L		L
0.5	L	L	L	D and L		L
0.7	Af	Af	D	D and L		D
0.9	D	D	D	D		D
1.0	D	D	D	D		D
1.2	D	D	D	D		D
1.5	D	D	D	D		D
2.0	D	D	D	D		D
0.0*	L	L	L	L		L

* Control sample.

TABLE 12

Effect of chlorine on protococcus forms (copper sulphate resistant)

CHLORINE DOSAGE	EFFECT OBSERVED (PERIOD OF CONTACT)				
	14 hours		24 hours		48 hours
	Residual chlorine	Algae	Residual chlorine	Algae	Algae
p.p.m.	*p.p.m.*		*p.p.m.*		
0.0	0	L	0	L	L
0.5	0	L	0	D	D
1.0	0.1	D and L	0	D	D
1.5	0.5	D and L	0	D	D

Table 7 indicates much the same information as that collected at Lufkin, namely, that a dosage of over 1.0 p.p.m. is required to effect killing of the organisms within six hours, whereas a dosage of 1.5 p.p.m. is effective within three hours and even as slight a residual as 0.05 p.p.m. will have some effect after twelve hours.

The two tables 8 and 9 taken together seem to indicate that even small dosages of chlorine are effective after a period of time and seem to exhibit an effect that is not immediately observed.

Data in table 11 indicate the difference in the immediate and after result of chlorine treatment. Periods of contact with the chlorine of one, six, and forty-eight hours were allowed, after which the excess or residual chlorine was neutralized. Examinations of the samples were made immediately after neutralizing the residual chlorine, and another two days later.

Table 12 covers experiments with protococcus forms which appeared especially resistant to copper sulphate treatment. From this experiment they appear to be susceptible to chlorination.

From these data chlorine appears to be an especially valuable agent in water treatment plants for the purpose of algae control in those cases where copper sulphate is not practical or efficacious.

SUMMARY AND CONCLUSIONS

1. Since chlorine can be employed as a combined bactericide and algicide, the expense of installation and operation of additional chlorination units is not excessive.

2. The residual chlorine which is necessarily maintained to insure sterilization becomes effective toward inhibiting algae growth.

3. The simplicity and economy of chlorine application and the minimum of labor and experience involved recommend its use.

4. Since chlorine does not remain in the treated water no danger exists in cases of over-dosing.

5. From the field and laboratory data chlorine appears to possess merits that make it worthy of greater consideration in algae control work.

In closing, we wish to emphasize the fact that this work represents only the results of a comparatively short period of study. The collection of additional information and data on this subject is desirable.

THE PITOMETER SURVEY IN THE IMPROVEMENT AND MAINTENANCE OF A DISTRIBUTION SYSTEM[1]

By Meyer Serkes[2]

The pitometer, which in recent years has been discussed so extensively in water works manuals, needs no introduction to water works men.

In 1912 the Water Division of the City of St. Louis adopted the pitometer as a means of detecting, measuring and curtailing its waste of water. At this time the Pitometer Company contracted to make several leak surveys in districts covering a greater part of our down town section.

In brief this survey is carried on in the following manner:

The distribution system is divided into districts of suitable size, depending upon the available feed mains, the class of consumers, location of valves and the fire hazard to be created. One main is selected to supply the district under investigation and all other feeds into this section are closed. The pitometer is placed upon this main to record the amount of water entering this district per twenty-four hours. From this record the minimum night rate between the hours of 12:00 midnight and 3:00 a.m. are compared with the total twenty-four hours consumption. Districts where the minimum night rate obtained is 40 per cent or less, would be considered as good tight sections; but if it were to run 50 per cent and over, such a district would be further subdivided and the excessive night rate of flow accounted for. The larger commercial meters would be read during the night period and accounted for in the study of the night flow.

In this further subdivision, sections are readily detected which are free from leakage. Sections which show small flows during the period of minimum night flow, indicate fixture leakage and would require a house to house inspection. Sections where large flows are recorded would indicate large water main leaks, service pipe leaks, or a larger number of fixture leaks.

[1] Presented before the Iowa Section meeting, November 4, 1926.

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All these conditions are thoroughly investigated by the pitometer engineer until all leaks have been located and repaired, after which the district is again remeasured to note the improvement made.

During the progress of such a leak survey much valuable information as to the condition and location of valves, hydrants, meters and other appurtenances of a system is collected, and the errors readily detected and corrected.

The results of such a survey in 1912 showed conclusively the advisability of continuing such work, and the department purchased several pitometers and has since maintained its own Pitometer Department which has been carrying on this routine leak detection work on a small scale to very good advantage.

During the past year a second class residential section was surveyed, in which the following leaks were detected: 371 faucet and toilet leaks, 3 service pipe, 3 fire hydrants and 10 street valves. These leaks constituted a wastage of 327,000 gallons per day or 119.6 million gallons per year. During the house to house inspections in this district, additional revenue was added, in that 381 automobiles and 161 washing machines, which are taxed on a flat rate basis, were placed upon the books.

The section investigated, comprising a population of 20,000, showed a consumption of 96 gallons per capita before, and 88 gallons after, the leaks were taken up.

These figures, which are far below the general average consumption of 145 gallons per day for the entire city, prove the section to be a good one and seem to indicate that the consumption in the industrial districts must be responsible for the increased per capita consumption.

In the early routine pitometer leak work it soon became apparent to us that a broader and more comprehensive use of the pitometer could be made in a study of the exact flow conditions existing during maximum and minimum periods of the day in all the main feeders of the distribution system.

Since this time the department has continued using the pitometer in making distribution feeder surveys yearly, whereby some mains were found to be doing no work whatsoever, and others as doing more than their share, with velocities higher than desirable causing excessive friction losses in the line.

These data obtained yearly are used to very good advantage in new distribution design, and in the modification of the existing system, so as to equalize the work by the various overtaxed feeders, thereby

enabling better pressures to be maintained at critical points in the system.

In one instance, a few years ago, it was observed, from pitometer flow readings, that none of the low pressure main feeders on and east of Grand Avenue, which supply the Compton Hill Reservoir, were taxed to capacity; that about 50 per cent of their total flow was supplied directly to the reservoir during the night period, between 6:00 p.m. and 6:00 a.m. The central feeder in this district, a 36-inch main on Twentieth Street, was observed to deliver practically no water from Chouteau Avenue southward, either during the day or night.

When the problem of providing a new outlet for a high pressure pump from Bissell's Point to a section in South St. Louis, which was giving us trouble during periods of high consumption, came up for consideration, it was decided to take advantage of the condition found to exist in this Twentieth Street 36-inch main and turn it into a high pressure feeder.

By some minor changes and disconnections from this Twentieth Street main, it was directly connected to the high pressure pump and made to carry water at the rate of 15 million gallons per twenty-four hours, into this critical section of South St. Louis, thereby avoiding the laying of a new 36-inch main as was proposed previously at a saving of $140,000 and increasing pressures about 14 pounds at this critical point.

The St. Louis distribution system, you may be interested to know, consists of two pressure systems, a high and a low, each being separated in the system merely by the closing of certain valves. The high pressure system renders service to the higher elevations in the west and southern parts of town, while the low pressure takes care of the lower elevations in the east or downtown sections and the extreme south. The high pressure starts with 120 pounds at Baden Station and the low pressure with 80 pounds at Bissell's Point.

In another case it was observed that a 30-inch low pressure feeder in Forest Park Boulevard from Grand Avenue to Sarah Street was carrying an almost insignificant amount of water. By a few additions and cross connections to this main it was taken out of low service and turned into a high pressure feeder so as to augment a 36-inch high pressure feeder across Grand Avenue which was congested during periods of large consumption between Bissell's Point Station and a point south of Olive Street.

During the past spring when an important 36-inch cross town

feeder had to be shut down in a certain section to make repairs, it was thought that an existing cross connection to this feeder, just north of the point where the repairs were to be made, would divert most of the water eastward, and into another cross town feeder which was not taxed to capacity.

Upon checking up with the pitometer the estimated flow that this cross connection was to carry, it was discovered that the main carried no water, whatever and, immediately upon checking the valves on this line, we found a valve closed which was supposed to be open.

Last year a pitometer flow survey was made upon all the high pressure feeders of 20-inch and over, in which valuable data were obtained, whereby recommendations were made for changes now in progress to the present system. When completed and inter-connected with the new Missouri River source, these will give a direct supply to those sections in South and West St. Louis which are urgently in need of relief.

The use of the pitometer, therefore, as you see, is an important factor in the study of the correct functioning of a distribution system.

A number of years ago an extensive pipe cleaning program was undertaken to reduce the friction losses and to restore the carrying capacities of some of our oldest mains, which have been in service previous to the installation of our rapid sand filtration process.

In this work the pitometer was used extensively in determining the pipe coefficients, friction losses and carrying capacities of the various mains before and after cleaning.

The contractor guaranteed to restore the carrying capacities of mains cleaned to within 5 per cent of that of new pipe, using Weston's table of flows as a basis. Tests made upon some of the mains, before cleaning was started, showed carrying capacities from 40 to 60 per cent of new pipe and tests run immediately after the cleaning showed gratifying results of 95 per cent of new pipe.

These same mains were retested year after year until today some of them have dropped as low as 70 per cent, although most of the larger mains have held up to a much higher percentage.

The intention of the Cleaning Company at that time was to restore the pipe to its original diameter by getting out all the hard lime incrustation and mud, regardless of the condition in which the interior of the pipe was left. Because most of this lime scale was hard and adhered to the pipe very tightly, the contractor constructed what was called "saw tooth blades," which were very sharp and stiff,

so as to make sure that they would remove everything and they certainly succeeded. They removed not only the lime incrustation, but also most of the tar coating which adhered to the bottom of the lime scale. In doing this the bare metal was exposed to the water and an iron incrustation immediately formed causing very rapid depreciation.

I understand today, however, that, from the experience gained here and elsewhere, this company is much better equipped to clean pipes, as they now make a complete study of the character of the water supply and plan the kind of a machine and the type of blade to be used to meet the local condition.

In many cases where it is expensive and difficult to take a large meter out of service for testing in the shop, the pitometer is resorted to in making a test in place with extreme accuracy.

A few years ago, in making such a test, a 6-inch meter was found to under-register about 15 per cent. This error was caused by an inexperienced meter man who made a change in dial gears in the field after making a small flow test. Since this meter supplied a very large consumer of water, the amount of unregistered water was estimated and a bill for several thousand dollars was presented and collected without much difficulty when the details of the incident were explained.

Again during the war period, the Government, which purchased water from us for its reservation through two 6-inch meters in parallel, disputed the correct registration of these meters, by a check at their Venturi meter in their pump station.

A test with the aid of the pitometer proved that our meters were within the limits of accuracy required and that the error was in the indicating device of the Venturi meter.

Such tests as these, where disputes occur and which are made in direct observation of a consumer, leave no doubt as to the merits of the case.

The problem of curtailing the waste of water, which invariably occurs in all unmetered cities and towns, is receiving more attention from engineers and water works officials today than ever before, owing to the fact that additional plant equipment and new sources of supply are becoming very costly.

The records of consumption in many cities clearly indicate that the amount of water wasted daily often far exceeds the quantity really

necessary to meet ordinary demands. This waste results largely from the fact that most consumers fail to appreciate the value of an unchecked, abundant, pure water supply.

This excessive use of water not only reduces the pressure, which is felt immediately at the critical points of a system, but also increases the cost of pumping and taxes a plant to its utmost capacity. A breakdown at such a period would create a hazard.

During the past dry summer, when sprinkling was the general order of the day, our plant was taxed to its capacity of 160 million gallons daily and it became almost impossible to maintain pressures at some of the critical high points. As soon as the excessive sprinkling was discontinued, however, the plant output dropped back to its normal capacity of 130 million gallons daily and the average pressure increased from 5 to 15 pounds at critical points.

A legitimate use of the garden hose would not cause such an excessive waste. The unmetered or flat rate consumer, who allows his hose to run continuously all day long and has no idea of the real value of a good water supply, is one of the prime causes of excessive waste.

This same condition exists during the near zero weather in winter when faucets are allowed to run during the night, to prevent freezing of service pipes.

Since St. Louis is only 7.6 per cent metered, you can observe for yourself why our plant is called upon at various times of the year to deliver its rated capacity.

The excessive waste in St. Louis may be attributed to the following causes:

1. Leakage from defective plumbing and fixtures.
2. Excessive sprinkling and the promiscuous opening of taps.
3. The extensive use of free water in city institutions and parks and needless industrial waste.
4. Leakage from the underground system of pipes.

Leakage from defective plumbing and fixtures may best be controlled by systematic house to house inspections, regularly maintained by a permanent staff of intelligent inspectors, with the aid of the aquaphone, by good plumbing ordinances, or by the universal installation of meters.

Excessive sprinkling can best be curtailed by the enactment of laws restricting the use of the hose to certain periods of the day.

Extensive use in city institutions and parks can best be restrained by a closer coöperation between department heads and the water division. In one city institution alone a million gallons per day is used of which 30 to 40 per cent is purely waste.

At one fountain in a certain park, $\frac{1}{2}$ million gallons are wasted daily. Such waste as this in parks and industrial plants could readily be conserved by the installation of a recirculating pumping system at a small initial cost.

The detection and the conservation of leakage in the underground system require the services of experts trained in this line, who can make an extensive pitometer survey.

The four means for reduction of excessive waste, which I have mentioned, have their particular merits. All remedies except the installation of meters are of a temporary value only and must be constantly repeated, and above all must be supported by strong laws and good plumbing ordinances to be effective.

There are many good reasons for the use of water meters. One of the most important is that selling water by measurement is the only logical and business-like way. This method is now used by all private utility corporations and should be likewise used by all municipal utility departments. It is the only method that does not result in gross inequalities and discriminations against some of the consumers in favor of others. Another reason is that the installation of water meters is the only practical method yet devised for restricting excessive waste.

The use of meters is now becoming much more general and in most cities today the large consumers, at least, are now metered. Here in St. Louis where we are 7.6 per cent metered, any connection other than one $\frac{3}{4}$-inch tap, which is now installed, requires a meter. Our present consumption per capita is 145 gallons. Under a totally metered system it woud probably be 100 gallons per capita.

I would not hesitate to estimate that the loss or waste of water due to small unmetered consumers averages 50 to 60 per cent of the total amount of leakage. The general use of meters should be the watch-word of the day in a modern water works system.

Usually there is a great deal of opposition raised to the introduction of meters, but in most cases it has been found that after they had been installed the good results which were immediately obtained caused them to be greatly favored by a community.

The general installation of meters in the following cities of Detroit, Milwaukee, Cleveland, Rochester, Baltimore, Los Angeles, and Atlanta, Ga., has in recent years greatly reduced the per capita consumption in these towns, thereby enabling a tremendous saving to be made in the cost of pumping, extension to the distribution system and in the chemical treatment of the water.

METER MAINTENANCE METHODS[1]

By J. H. Fagg[2]

For the purpose of this report a survey was made by means of a questionnaire returned by twenty-eight water companies in California, whose services were metered 80 per cent or over, and involving a total of approximately 640,000 services.

Of these twenty-eight, thirteen plants were municipally operated, and fifteen operated by private companies.

The questionnaire produced the following information:

1. Fifteen companies check all new meters for accuracy upon receipt.
2. Twenty companies use the round reading dials, and the cubic foot, with one exception, is the unit of measurement.
3. Only five are continuing the use of compound meters.
4. Fifteen of the twenty-eight are using batteries of small meters on the larger services.
5. But three of the companies test their meters periodically: one on a two-year schedule, one on a three-year schedule and one every four or five years. Also 2 remove their meters for test and overhauling after one complete revolution of the dial.
6. Practically all of the companies use the concrete meter box and set meters just inside of curb line where mains are carried in the street.
7. Eleven of those reporting are employing check valves to prevent hot water damage and bill consumers the cost of repairing the damage caused by hot water.

In analyzing the return on the questionnaire it appears that most of the companies realize the importance of testing new meters when received, and from the tone of some of the statements it is believed that it will soon be general practice to test all meters periodically.

The round reading registers are giving the best satisfaction, as they will operate over longer periods than will the straight reader.

The use of compound meters is being discontinued rapidly by nearly

[1] Presented before the California Section meeting, October 28, 1926.

[2] District Manager, Pacific Gas and Electric Company, San Joaquin Division, Stockton, Calif.

all of the companies and the use of batteries of small meters on large services is becoming popular with most water works men.

A very small percentage of those reporting are making a practice of testing meters in the field, and they have equipped their shops with standard test tables of standard manufacture and other necessary facilities for proper handling of meter repairs.

SOLVING THE SEAGULL PROBLEM IN SAN FRANCISCO

By George W. Pracy[1]

The city of San Francisco is located on a peninsula with San Francisco Bay on the east and north, the Bay gradually narrowing to form Golden Gate Straits with the Pacific Ocean on the west. The city has always been more or less infested with seagulls along the water front, though up to the past few years they have not come inland. These birds are great scavengers and it is unlawful to kill them.

The Spring Valley reservoirs, located in various parts of the city, date back to the early history of the city and were all uncovered. About ten years ago the seagulls started coming into one of our small reservoirs not far from the water front. We tried to chase them out without any success. They became so bothersome that we finally covered the reservoir. The birds then spread to three other reservoirs farther in town. These reservoirs are larger and owing to the existing conditions are practically impossible to cover. We tried to drive the birds away by shooting and finally purchased an automatic exploder which was only fairly successful.

About two years ago, one of our fellows visited the city of Victoria in British Columbia and came back with the report that they had had trouble with seagulls and had effected a cure by stringing wires across the reservoirs in about fifty-foot squares. We immediately tried this on one of our reservoirs measuring about two hundred feet square, stringing the wires forty feet apart in both directions and found it was entirely successful in keeping the seagulls away.

We next strung similar sets of wires over a larger reservoir, being circular in form and about four hundred feet in diameter. This also being successful, we proceeded to string wires over our largest reservoir which is irregularly shaped, but about one thousand feet long by six hundred feet wide. In the first two reservoirs, we used the ordinary No. 9 galvanized iron wire, commonly known as tele-

[1] Superintendent, City Distribution Department, Spring Valley Water Company, San Francisco, Cal.

phone wire. These were fastened to 2 inch pipe driven into the ground. On the large reservoir, we felt that wires of this size would not stand the strain necessary to keep them taut over so large a span, so we first installed a system of larger cables, $\frac{1}{4}$ and $\frac{1}{2}$ inch in diameter, using these to support the small wires. Two pipe supports resting on the bottom of the reservoir and spaced about $\frac{1}{3}$ of the way across were used to shorten the span.

A system would have to be worked out in detail for each size and shape of reservoir, but in our case it was comparatively simple and worked perfectly. The wires are pulled taut, the net work of wires being about one foot above the high water mark in the low part of the span.

The small reservoirs cost us about $50 for the complete job; the large reservoir cost about $400. The results have been entirely satisfactory. We get an occasional seagull, but they appear rarely and they do not stay.

NOTES ON PUMPING AND WATER WORKS OPERATION[1]

By McKean Maffitt[2]

In compressing air it is a known fact that it gets hot due to the rearrangement of the molecules as they are packed closely together. You absorb heat into the air and it gets so hot that every air compressor of high capacity has some good method of cooling. If it has not some method of cooling, it will burn up.

An Ingersoll-Rand, two straight line air compressor, has a low pressure cylinder that pumps air through a cooler that is built very much on the type of a water works condenser. The air then goes from that cooler to a high pressure cylinder and is recompressed and reheated. This is a typical illustration. An air pipe leads to a large receiver where you store the air for use so that you will not have pulsations in your pipe lines leading to your wells. As this air goes from the compressor to the receiver it carries a quantity of oil—a high volatile oil having a high flash point. That is, it will not ignite except under very high temperature. This high flash point oil is used for the purpose of resisting heat. Where you have taken air at atmospheric pressure and increased it to 105 pounds gauge pressure you have seven times the oxygen in the same bulk of space as under the atmospheric pressure. For each particle of oil in that receiver there is seven times the oxygen that there would be in the atmosphere. If it gets too hot the air receiver is liable to explode and the result will be equivalent to a boiler explosion. It would not have the result that a boiler explosion would have, because a boiler contains a large quantity of water which immediately flashes into steam when the pressure is reduced. But most receivers will have a large quantity of oil that is very hot and which will almost instantaneously flash when the pressure is reduced and original combustion stops. That is one danger to which every air receiver is subject and one that should be carefully watched to see that there is not an accumulation of oil in the receiver.

As your pipe line comes from the receiver and goes to the well,

[1] Presented before the North Carolina Section meeting, August 23, 1926.

[2] Superintendent, Water Works, Wilmington, N. C.

it is absolutely necessary that every joint be tight because a leak of a cubic foot of air from a joint in a pipe line—going back through the air compressor and figuring the efficiency of the air compressor—will require the compression of two feet. If an air compressor is operating at 50 per cent efficiency—and I imagine that most of them are operating at less than that—that same 2 feet of air going back to the pipe lines, which might be operating at an efficiency of 90 per cent will still further be increased until the boiler is reached. If the boiler is operating at 60 per cent efficiency you still have no increase. You put under the boiler enough coal to compress 3, 4, or 5 cubic feet of air and you take out of the air compressor perhaps 1 cubic foot of air. The further you get away from your boiler, the more benefit you get from stopping any kind of leak or increasing any kind of efficiency.

When your piping goes into your well and goes down, if you have a very high lift so that you must have exceptional submergence, you must generate enough pressure in the air receiver to blow off or take the head of water. For instance, if the static head in the well is at the surface, the draft head is 100 feet below the surface. The submergence should be figured on the draft, and not on the static head, because the draft head should be so arranged that the submergence will be about 65 per cent of the discharge.

If you add to that 65 per cent discharge, one hundred feet of static head in that well, the air pressure must be raised sufficiently above the working pressure to throw off that 100 feet. In that case there should be an auxiliary line run down into the well point at the draft head, the auxiliary line to blow off the 100 foot static head. Then immediately, or at the same time, open your working head and allow the air to go down to the point of discharge as determined by theory and practice. That will give you the best operation for your draft head. Cut off your auxiliary head then and allow the working head to carry on.

Most of the text books I have found on compressed air pumping from deep wells claim that water and air come out of the well in solution. I imagine the reason they make that claim is because it is easier for draughtsmen to show a slug of water and a slug of air coming out of a pipe than it is for them to show the air and water mixed.

During my years of experience in operating wells I have never found that a well discharged a slug of water and a slug of air.

The claim is made that the air acts like a piston and pushes the water out of the well, but the air does not act like a piston and push the water out of the well. The air is supposed to mingle with the water, to be thoroughly diffused throughout the water, thereby lessening the specific gravity of the column of water to such an extent that the pressure of ground water can force more water into the pipe.

As this little column of air and water is created in the pipe line, it necessarily rises to a point where it overflows at the surface. That is what brings the water out of the well.

In a great many installations, the pipe line is put down into the well and the nozzle shoots the air into the well in a stream or jet effect, jetting the water out and losing efficiency. If the pipe line is put down into the well, capped on the end, and filled full of small holes $\frac{1}{16}$ or $\frac{1}{32}$ inch—if it is a copper pipe a little bit larger hole is desirable than with the galvanized or wrought iron pipe—this air will come out into the water in a series of very fine streams which will cause more or less of an emulsion of air and water, the specific gravity of which should be 50 per cent the specific gravity of water. Then your column of water 100 feet high will weigh twice as much as your column of water and air, thereby obtaining a 50-foot lift.

"KINKS" IN OPERATION

In nearly every case where a contractor comes to town to pave streets various troubles result. Among others, corporation cocks may be broken off at the main by the plow or the skimmer shovel. In cases of this kind I use a long steel tool squared and tapered at each end, one end to enter the inlet end of a $\frac{3}{4}$-inch corporation cock and the other to enter the end of a 1-inch corporation cock. I insert the proper end of the tool into the brass ferrule left in the main and drive it home rather snugly. A pipe wrench will enable you to back the ferrule out of the main. Now take a closed corporation cock, insert the outlet end in the coupling of the proper size galvanized pipe and you can screw the cock into the main against the pressure. In case the main is so shallow that the force of the water coming out of it will jet all of the water out of the hole you can use two heavy boards laid down across the hole. Cut a V notch in each board, bring these notches together just over the hole in the main and then work down through these notches to the main. It requires a little nerve and a good grip to get the cock centered in the hole, but it can

be done. I have found this was much better than cutting off the main, especially where it was a large main or one that supplied a manufacturing district. Then it is easier and cheaper. After you have inserted the cock in the main you can dig down to the cock and remove the pipe and then tighten the cock with a pipe wrench.

Some years ago we had a regular siege of blown out plugs. In some few months we had 5 16-inch plugs blown out. In every case it meant shutting down the plant until we could cut off the water. As our valves were not in good order at that time there was one case where we could not shut off the water tightly enough to work in the hole. All the trench pumps we had would not pump the water lower than half of the way down the bell. Do what we would, we could not get the hole dry enough to work in. I got a common screw jack and some heavy gum packing. I cut a gasket 1 inch wide, the diameter of the plug, tied this gasket to the face of the plug with cotton string and then inserted the plug in the bell, using the jack to force it to a seat against the gasket. This held the water tightly enough for me to yarn and pour the joint. The hole was practically dry after I had jacked the plug up against the shoulder in the bell. I have used this trick several times and each time it works more easily than it did the first time.

Some years ago I had a leak reported on a 12-inch main. When we opened it up we found that the spigot end of the pipe was cracked. The crack ran about 18 inches out of the bell. Rather than cut this section I used two clamps made of $\frac{3}{4}$-inch by 2-inch flat iron. These clamps were made in two sections, one-half circle in each section, with 3-inch lugs on the ends and 1-inch hole bored in each lug. The whole clamp is made so that it is a snug fit with about two inches clearance between the lugs when it is placed around the main. Use long threaded bolts through the holes in the lugs, first drawing tight the clamp further away from the bell, then tighten the next clamp. As you start to tighten the clamps, if you will take two light round pien hammers and lightly tap the pipe just on each side of the crack, you stand a better chance of getting a good tight joint, as the vibrations of the hammer blows cause the ragged edges of the iron to seat together more evenly.

In case the crack happens to be in the body of the pipe and not at the end, you can do the same thing. It is better, however, to start the two end clamps first, working gradually towards the center, that is, if it requires more than two clamps. The clamps should be spaced

about 8 to 12 inches apart, depending upon how bad the crack is. If the crack is ragged and uneven there is no chance of making a fit. If the crack happens to have been caused by a blow from a pick and the pick stuck through the main, work the crack up to the hole caused by the point of the pick and then put a heavy lead gasket over the hole and a clamp over the lead gasket and draw the clamp up tight. Of course, you will get wet and all these cracks will happen in the winter time and at night, but then it is easier than to cut out a section and it costs about $\frac{1}{8}$ as much.

If any of you run a steam plant and have a number of small leaks in your steam lines that are too small to shut down to repair, or are such that one of these patent clamps will not take care of it, try this. Right at the boiler, in the horizontal pipe line, tap a small hole in the steam line. Insert a regular drip lubricator. Fill the lubricator with a mixture of cylinder oil and fine flake graphite. Make the mixture so that it will barely feed. Open the lubricator and let the mixture feed slowly into the line all the time. Attend this lubricator as regularly as you attend the lubricator on the main pump. In a few days you will fail to see any of those small steam leaks. The flake graphite will be carried into the crevices by the escaping steam and will effectually plug them up. If the graphite goes on over to the pump it will act as a better lubricator than the cylinder oil will.

In case you were tapping the main and should insert a corporation cock that was open you could not get the machine off the pipe without getting wet. I have done that very thing and got a good ducking from it. The next time this happened—and it will happen some times—I simply stripped the machine off the boring bar and then cut off the water at the cock and removed the bar. If you are very careful, remove the collar from the top of the boring bar of the tapping machine, take the upper part of the machine off over the boring bar, then remove the lower part of the machine the same way. It will leave the cock in the main and the boring bar in the cock.

In patching paved streets where there is a dense traffic and it would be inconvenient to leave the hole blocked off for some time while the concrete set up, I tried the following method: tamp the hole until it is as solid as you can make it. Make a mixture of concrete the same as usual only not so wet. Make it the consistency of stiff putty. Put this in the hole and tamp it hard. I mean hard, not just light taps. Tamp it until it is almost impossible to make an impression on it with the tamping iron. Put your top surface down

on this tamped concrete. Bricks, sheet asphalt, Hastings asphalt blocks, Kentucky Rock asphalt or any other kind of surfacing. Cover the finished surface with about one inch of loose sand and open it to traffic. Nothing short of a ten ton load will affect it. There are about fifty such places here in Wilmington. It worked out so well that even on those streets where there is very little traffic we do the same thing. We never block off a paved street for the regulation ten days. Only just so long as it takes us to put in the material.

If any of you have charge of a sewer system this might be of interest to you. We had to run a sewer line to a section that had about twenty houses in it. To get to this section the line came to the surface of the ground. It was simply a case of leaving out this section or putting in an invert. So I tried the invert. I ran the line at the regular grade until it was within 6 inches of the surface. Then I built a man hole. The inlet lines to the man hole were put 24 inches below the outlet line. Thus the sewage had to rise 24 inches in the man hole before it would run out. The laterals on the low line were run out to the property line before any houses were connected up. At the ends of the two low lines there were installed flush tanks so that we could get a large flush of water once in a while. In the man hole at the break in the grade we installed a 1-inch water connection in such manner that we can turn the water on and break up the accumulation of sewage that collects here. About once every two weeks in inspecting sewers we go to this man hole and break up the scum and wash it down the sewer. This line has been in operation about two years and has not given any trouble. We deemed it best to have this lie this way than to have this section of the city using separate septic tanks that were always giving trouble.

We installed a line of Universal some time ago and the foreman in charge was a little skittish about the joints and had them pulled up hard and tight. About three years after installation trouble began to develop in every cold spell. We found that in taking out a broken section we were lucky if we got by without breaking at least five spigot ends. Thus there were always 25 feet of pipe that were wasted. That being too expensive, I had these flanged sleeves made and in case we have a Universal joint that leaks we put this around the joint, bolt it tight onto a lead gasket, yarn and pour the same as we would any other joint and that is the end of our trouble. About a week ago we had a 6-inch B. & S. line slump off the side of a hill and pulled a spigot so far out of the bell that you could stick a pencil into the

joint. As it was impractical to straighten the line just at that time, we tried one of these joint sleeves and it worked so well that for the time being we have left the line as it was.

If any of you have any wrought iron lines that are pitted so bad that they develop leaks all over at once and it is not convenient to cut them out or relay them and they are so rotten that it is practically impossible to thread the pipe I know what you are up against. One of these small holes will make a bad place in the pavement, although it will not waste 100 gallons of water a day. It has to be repaired and it means taking out the whole line or at least one whole section so that you will not have to thread the pipe. If you will take a piece of soft white pine, taper it down to about the size of the hole in the pipe. Stick it in the hole and drive it in slightly. Draw it out and by examining the end that was in the hole you can get the exact shape of the hole. Now cut the stick so that it will have a slight taper and will be shaped almost like the hole in the pipe. Stick it in the hole and drive up rather tight. Be careful that you do not crush the stick, just tap it lightly until you have the leak stopped. Then carefully cut the stick off about ½ inch from the pipe and go home and to bed. That stick will stay there as long as the main does. There is one line of pipe in South Carolina that looks like a porcupine, if it is still in the ground. I put about 50 sticks in it and when I left there the man in charge was putting in sticks.

Some months ago we had a considerable wash-out at a bridge. A 12-inch main joint blew out and before we could shut the water off it had washed out a bridge abutment. This abutment was 30 feet long, 24 feet high and 7 feet thick at the base. We decided to under-pin it rather than tear it down and rebuilt it. We jacked one end of the bridge off the abutment and proceeded to underpin. It was a ticklish job. The sub-grade was of loose sand. If we got below the blocking we had put under the abutment we were in for the loss of the whole thing and maybe the bridge too. As we poured the concrete under this abutment I found that it was practically impossible to pack it hard up against the brick. The more we tamped it the looser it got. It looked as if there was no chance, but to let the brick work settle about ½ inch more as it came down onto the concrete. We did not want this to happen as the abutment was about one inch low already. I built my forms up in front of the cavity and poured them as full of concrete as I could. Still the concrete was not making a good joint with the overhead brick work. Then I took two

pieces of 2-by 8-inch lumber dressed all around and sharpened at the ends. I cut holes in the forms that would let these pieces of lumber go through and then I drove these pieces into the mass of concrete just as close up to the brick work as I could get them. As they were driven into the mass of concrete they displaced just so much concrete and as there was no where for it to go but up, up it went and filled in that small cavity. After the concrete had set I pulled the forms and examined the joint between the concrete and the brick work and found that the brick work had almost as good a bearing on the concrete as if it had been put on the concrete instead of the concrete having been put under the brick work.

DISSOLVED OXYGEN CHANGES DURING FILTRATION[1]

By W. U. Gallaher[2]

In connection with experiments conducted at the Highland Park water filter plant to locate the cause of air-binding in filters, the dissolved oxygen was run on a sample of the water entering the filter bed and also on a sample taken from the effluent pipe of the same filter. An interesting fact was discovered. There was a decrease in dissolved oxygen, even though the filter on being washed did not show any entrapped air. This decrease was also evident when the water was not supersaturated with oxygen. It was decided to run a series of tests at intervals during the year when the water was at different temperatures and discover if the temperature had any effect on the decrease in dissolved oxygen during filtration.

There are few references in the literature dealing with changes in the dissolved gases of waters that are subjected to sand filtration. This is probably due to the fact that the changes are small, have no apparent practical importance, and vary (as in the case of most water problems) with the quality and treatment of the water. This means that numerous accurate determinations must be made before fair conclusions can be reached.

In Germany, Noll (1) made a very extensive and accurate study of dissolved oxygen changes on filtration and found that the change in dissolved oxygen in passing through sand filters was greater than the changes in the oxygen consumed. He states the oxygen may have been used up as follows: (*a*) by the bacteria, (*b*) by chemical reactions within the filters, or (*c*) by escaping from the filters. However, he attached little importance to the last possibility.

The raw water source at the Highland Park plant is the Lake St. Claire and is therefore a typical Great Lakes water. Its quality is practically the same the year round and it is an ideal water on which to make the determinations reported in this paper. It is pumped 11 miles before filtration against a 43-foot head, the pressure at the

[1] Presented before the Central States Section meeting, September 21, 1926.

[2] Superintendent of Filtration, Water Department, Highland Park, Michigan.

discharge of the pumps varying from 45 to 105 pounds per square inch. Hatfield (2) has previously reported how air-binding was traced to defective water seals on the lake pumps.

The mixing of air with water and immediately subjecting them to pressures greater than atmospheric causes the gas to go into solution in higher concentrations than when the water was in equilibrium with the atmosphere. Even after the water is exposed to atmospheric conditions in the coagulation basin the return to equilibrium is slow. On passing through the filters the return to equilibrium is hastened, air is released and accumulates in the voids of the sand and gravel. Baylis (3) states that the starting of release of air in filter beds is due entirely to bubbles being carried into the bed or to air left in the bed after washing.

It has not been proven that temperature has any relation to air-binding. Caird (4) reported that the release of air in filters occurred during cold weather when the water was at a temperature below 50°F. It is more generally conceded, however, that air-binding depends to a great extent on the handling of the water prior to treatment.

The procedure for the tests made was as follows: Samples were taken in triplicate of water on top of the filter and the temperature recorded. Immediately afterward three samples were taken from the effluent pipe of the same filter and the temperature recorded. All samples were taken in 250 cc. glass stoppered bottles and the dissolved oxygen determined according to the procedure given in the A. P. H. A. "Standard Methods for the Examination of Water and Sewage." Samples collected at low temperatures were placed in the ice box until final acidification to prevent any loss of oxygen.

Table 1 is a complete list of the determinations made. The figures given are the average of the three samples taken. Column T–E represents the diminution of dissolved oxygen on passing through the filter expressed in per cent saturation and column OT–OE gives the decrease in dissolved oxygen expressed in parts per million. Samples marked *a* and *b* are from the filter during the same run, sample *a* being taken at the start and sample *b* near the end. No change in concentration of carbon dioxide was detected. The dissolved oxygen of the raw water was run at first, but on account of several hours detention in the coagulation basin there was some variation between the raw and influent samples. However they were not found necessary in interpreting results.

TABLE 1

Dissolved oxygen before and after filtration

NUMBER	TEMPERATURE	PER CENT SATURATION			OXYGEN			SAMPLING FROM START	LENGTH SERVICE
		Top	Effluent	T–E	Top	Effluent	OT–OE		
	°C.				p.p.m.	p.p.m.	p.p.m.	hours	hours
1	0.8	100.8	101.3	−0.5	14.42	14.50	−0.08	15½	24
2	0.8	99.5	98.7	0.9	14.25	14.12	0.13	3	28
3	0.8	98.8	98.0	0.8	14.13	14.03	0.10	4	28
4a	0.8	99.9	99.2	0.7	14.28	14.19	0.09	2	28
4b	0.8	99.9	96.4	3.5	14.28	13.79	0.49	26½	28
5	0.8	100.6	100.6	0.0	14.39	14.40	−0.01	3	25
6	0.8	97.3	96.7	0.6	13.93	13.88	0.05	10	26
7	0.9	101.1	100.9	0.2	14.43	14.40	0.03	4	26
8	1.0	98.0	98.2	−0.2	13.95	13.97	−0.02	20	24½
9a	1.0	100.2	99.4	0.8	14.26	14.15	0.11	5	27
9b	1.0	105.41	97.0	8.4	15.00	13.80	1.20	26	27
10	1.0	103.9	99.4	4.5	14.79	14.15	0.64	4	27
11	1.0	98.0	97.8	0.2	13.94	13.92	0.02	29½	32
12	3.3	100.3	99.0	1.3	13.42	13.25	0.17	3½	23
13	4.0	99.6	98.3	1.3	13.08	12.90	0.18	25	26
14	4.0	99.8	99.2	0.6	13.10	13.03	0.07	22	23½
15	6.0	94.4	93.1	1.3	11.77	11.60	0.17		
16	6.5	95.9	93.3	2.6	11.82	11.49	0.33	2½	26
17	7.0	96.6	94.2	2.4	11.75	11.46	0.29	6	31½
18	7.0	95.1	93.4	1.7	11.56	11.36	0.20	24	30½
19	7.5	97.0	95.0	2.0	11.68	11.47	0.27	28	31½
20	8.0	96.1	94.4	1.7	11.40	11.20	0.20	28	30
21	10.0	93.0	91.3	1.7	10.54	10.35	0.19	22	29
22	21.0	90.2	85.3	4.9	8.10	7.66	0.44	8	28
23	21.0	91.7	86.8	4.9	8.10	7.74	0.36	7	29½
24	22.0	92.3	87.3	5.0	8.15	7.71	0.44	7½	25
25	22.0	93.0	86.6	6.4	8.21	7.65	0.56	22	30
26	22.0	93.9	91.1	2.8	8.25	8.00	0.25	4	27
27	22.0	96.5	91.4	5.1	8.51	8.08	0.43	12	22½
28a	22.5	92.7	88.9	3.8	8.11	7.78	0.33	4	27
28b	22.5	93.6	91.0	2.6	8.19	7.94	0.25	23	27
29	22.5	101.3	97.8	3.5	8.87	8.55	0.32	10½	22
30	22.5	97.4	92.5	4.9	8.62	8.10	0.52	4	24

One can readily see that there is a gradual increase in the amount of oxygen removed by the filter as the temperature of the applied water increases. For the purpose of making a better comparison the results were averaged over narrow ranges of temperature and are shown in table 2. The average results were then calculated to cubic centimeters per liter and to cubic feet per million gallons. The last column represents air equivalent to the oxygen, assuming that the former contains 21.0 per cent of oxygen.

What becomes of the oxygen lost during filtration? It is reasonable to suppose that some of it is used up in biological reactions in the filter bed. These reactions would be more complete as the temperature increases. Therefore, more oxygen will be removed during the summer than during the winter. Whether or not all is used in this manner has not been settled. It is unfortunate there is not a titrimetric method for the determination of nitrogen. An accurate determination of gases other than oxygen might give a better idea whether or not air actually escapes from the water during filtration in cases where air is not found in the bed on washing. The boiling out method can be used, but is rather cumbersome for making large numbers of determinations. The author hopes to perfect an apparatus for collecting any released gases from the filters. An analyses of these, if there are any, may give information as to what actually happens in the filter bed.

TABLE 2

Averaged decreases of dissolved oxygen

Temperature		OT–OE average	Oxygen per liter	Oxygen per million gallons	Air per million gallons
Range	Average				
°C.	°C.	p.p.m.	cubic cm.	cubic feet	cubic feet
0.8– 1.0	0.9	0.04	0.02792	27.9	133
3.0– 3.4	3.8	0.14	0.09772	97.7	465
6.0–10.0	7.5	0.24	0.16752	167.5	798
21.0–22.5	22.0	0.40	0.27920	279.2	1,330

Observations other than chemical indicated that although temperature may have some relation to air-binding it is not the sole cause of it. Air was occasionally present at all temperatures, although during the last two years it is most prevalent during the summer months. The reason for this can be traced to the handling

of the water before filtration. The negative head under which the filter works and, as Baylis pointed out, the introduction of the first air bubbles in the filter are suggested as possible causes for air-binding. A supersaturation of air in the applied water is also conducive. For example, in the case of numbers 4b, 9b, and 10 in table 1, the reduction in dissolved oxygen is more than average at the end of the run when there is the maximum negative head or where there is a supersaturation of dissolved oxygen in the applied water.

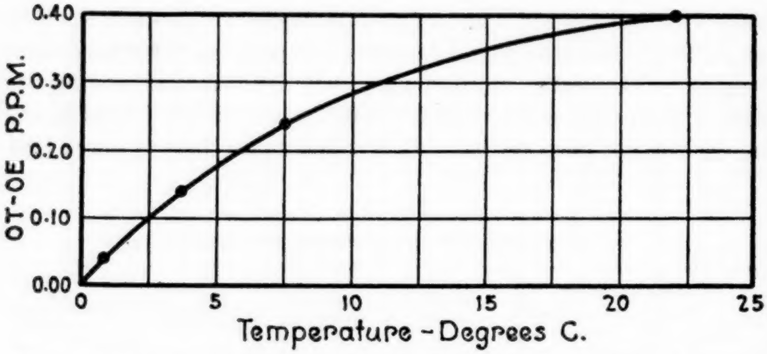

Fig. 1. Relation of Temperature to Decrease of Dissolved Oxygen by Sand Filters

A small part of oxygen determined by laboratory tests represents a large volume of air in a million gallons of water. One-tenth of a part per million of oxygen is equivalent to 330 cubic feet of air in a million gallons of water. If one is using dissolved oxygen determinations as a basis for judging the amount of air released during filtration a correction should be made for the oxygen normally removed from the water by the filter at that temperature.

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(3) Baylis, J. R.: Influence of curvature on air saturation of water and its relation to the air-binding of filters. Jour. Ind. and Eng. Chem., **17**, 974 (1925).

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IMPOUNDED WATERS AND MALARIA

Editorial Comment

Within the past two years LePrince has called attention, in the pages of the Journal,[1] to the dangers associated with the impounding of water in large areas, in so far as such areas may bear some relationship to epidemic malaria. Although these discussions might have impressed some readers as of only academic importance, recent investigations of the problem, particularly in the southern portions of the United States, have demonstrated the important duty imposed upon water works designers in the protection of the health of populations adjacent to impounded water areas. The progress in water power development, particularly in this country in recent years, has given increased emphasis to the necessity of providing against the sharp rise of malaria during or after the completion of such impounded areas. Exactly analogous conditions may likewise be established in impounding large areas for potable water supply purposes.

In view of these warnings and suggestions by LePrince in This Journal and by other investigators in other publications, the recent observations[2] by Smillie in Alabama appear to deserve editorial comment. This investigator has had a unique opportunity to observe, over a period of three years, the relationship between impounding of water and the increased occurrence of malaria at Gantt, Covington County, Alabama. These observations extend from a year previous and two years subsequent to the impounding. In the spring of 1922 a power company began the construction of a dam across the Conecuh River at Gantt Village, with a population of about 250 people. The construction work on the dam progressed slowly during 1922, with the completion thereof requiring the greater part of 1923. The State Board of Health of Alabama established certain regulations for the procedures to be used in controlling the breeding of mosquitoes in the waters impounded. Controversial

[1] Journal, January, 1926, p. 35; January, 1927, p. 31.

[2] The American Journal of Hygiene, January, 1927, vol. 7, No. 1, page 40.

difficulties between the power company and the State Board of Health, as to the details of the application of the State regulations at the reservoir, resulted in incomplete clearings of the impounded areas at various heights and considerable raising and lowering of the water surface by the power company during the period of construction. In November, 1924, the company and the State authorities finally reached an agreement upon the methods to be used in protecting the surrounding population against mosquitoes and malaria, so that the Company agreed to lower the river to its original bed by April 1, 1925 and to comply with the State regulations before reimpounding.

The sanitary results of these engineering and diplomatic negotiations are amply set forth, without comment, in figures 1 to 6. They demonstrate the necessity of precautions on the part of the designing engineer to prevent malaria after building works for impounding water.

ABEL WOLMAN.[3]

[3] Editor, Journal of the American Water Works Association; Chief Engineer, Maryland Department of Health.

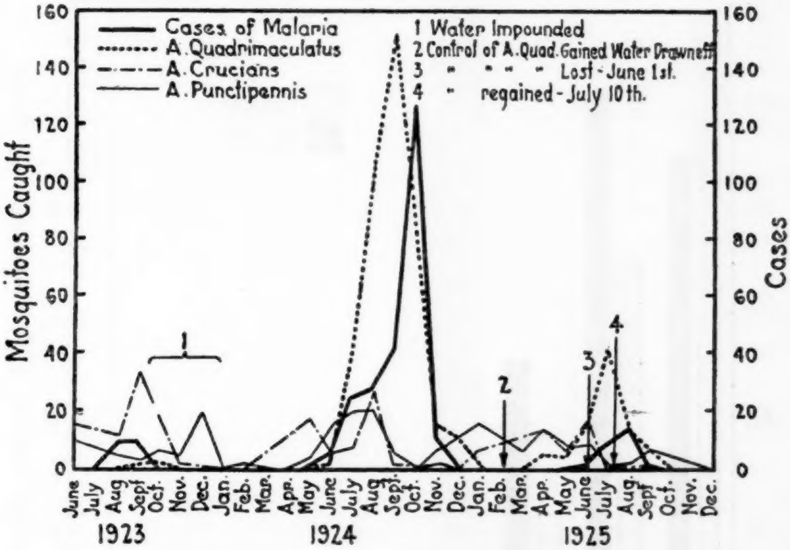

FIG. 1. ANOPHELES DENSITY AND CASES OF MALARIA IN THE GANTT AREA, ALABAMA, BY MONTHS IN 1923, 1924 and 1925

The increase in anopheles mosquitoes in 1924 followed the impounding of water without adequate mosquito control measures. The close relationship between rise in numbers of A. quadrimaculatus and increase of malaria shows that this mosquito was the principal vector.

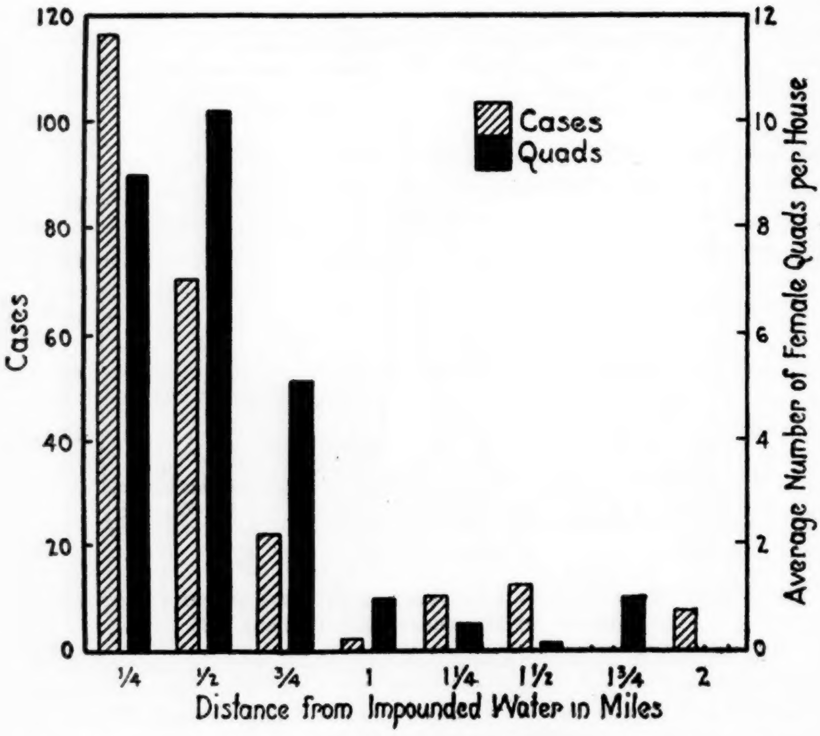

Fig. 2. Relation of Malaria Cases and of Density of Female A. Quadrimaculatus to Distance from Impounded Water

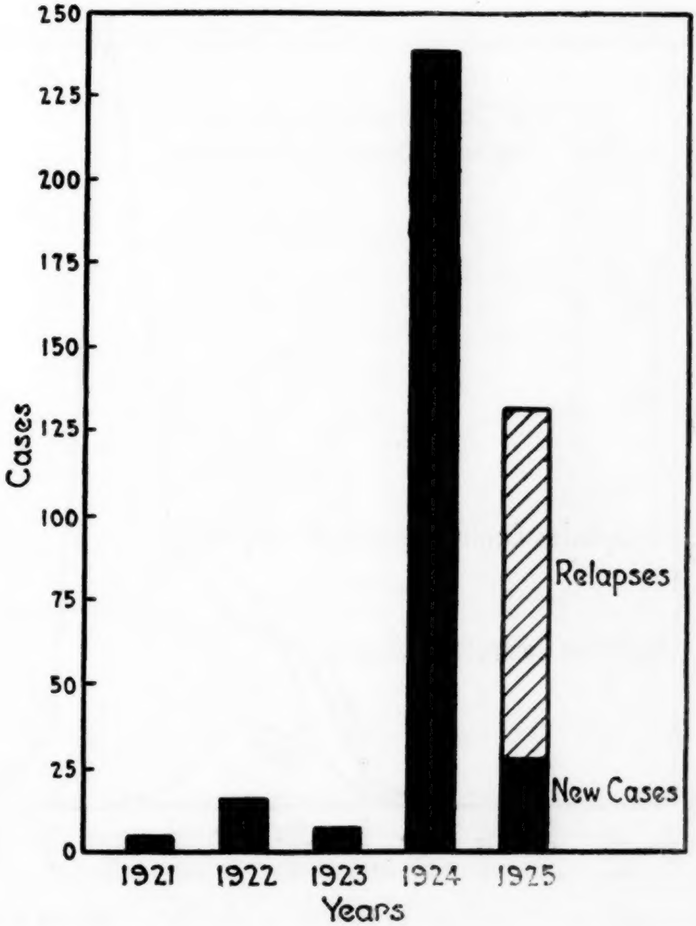

FIG. 3. YEARLY INCIDENCE OF MALARIA FOR THE GANTT AREA FROM 1921 TO 1925

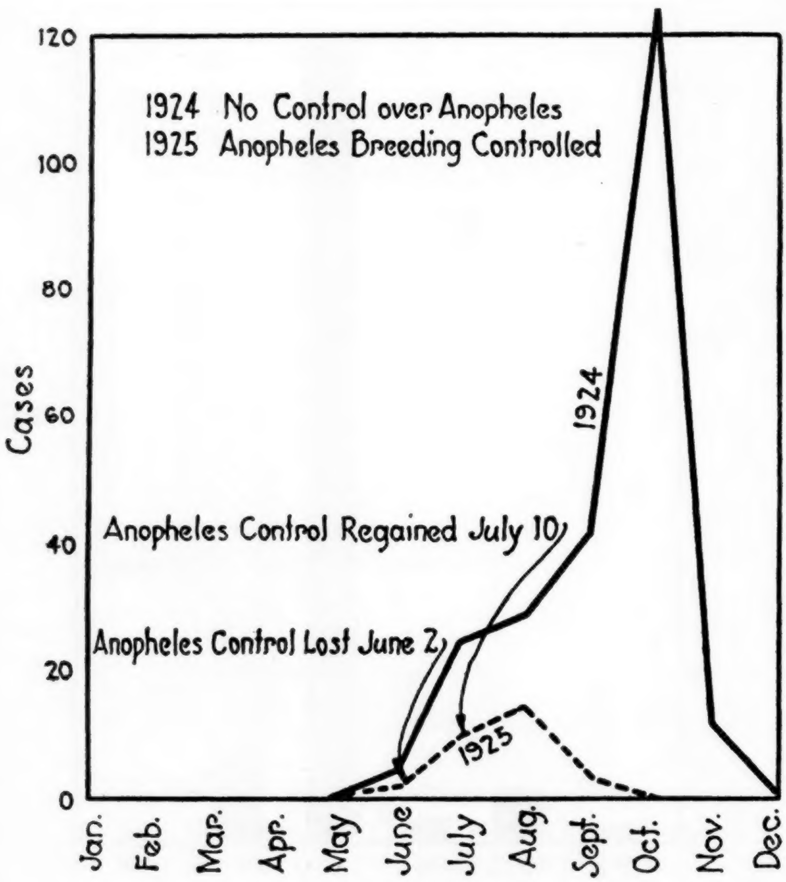

FIG. 4. INCIDENCE OF NEW CASES OF MALARIA DURING 1925, COMPARED WITH INCIDENCE OF CASES IN 1924

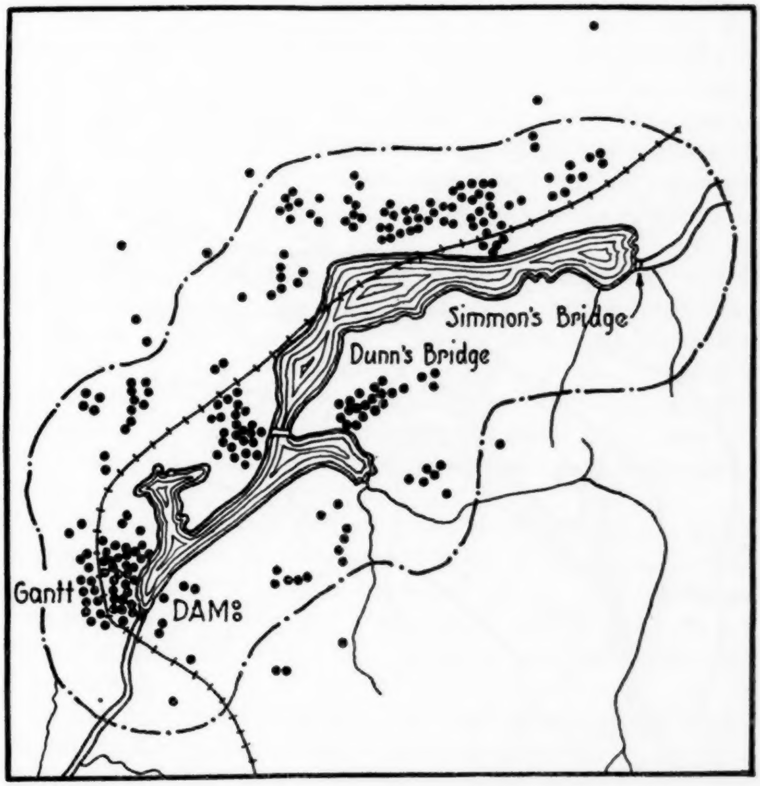

Fig. 5. Epidemic of Malaria at Gantt, Alabama

Map of impounded area, 1924. Dam to Dunn's bridge, partially cleared; Dunn's bridge to Simmon's bridge, uncleared. The line is drawn 1 mile from high water mark of the margin of the pond. Each dot represents a case of malaria.

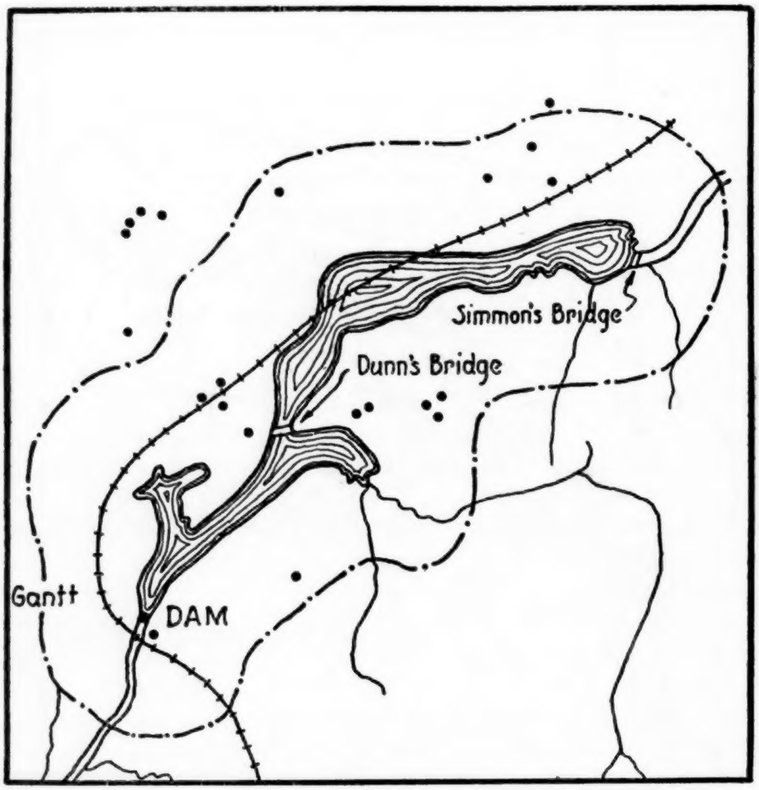

FIG. 6. DISTRIBUTION OF MALARIA AT GANTT, IN 1925

Map of impounded area, 1925. Dam to Dunn's bridge, cleared; Dunn's bridge to Simmon's bridge, partially cleared. The line is drawn 1 mile from high water mark of the margin of the pond. Each dot represents a case of malaria.

SOCIETY AFFAIRS

MONTANA SECTION

The second annual meeting of the Montana Section, was held in Billings, Montana, January 7 and 8, 1927. Mr. Willett, section president, was in the chair. The Billings city water department, of which Mr. Willett is superintendent, was host and entertained all in a royal manner. Starting with registration and an executive committee meeting Friday morning the session extended until late Saturday afternoon.

At the executive committee meeting a policy of committee organization and work during the interim between meetings, was fully discussed and agreed upon. Every member upon some committee for constructive study of various problems is the aim. That this second meeting was an extremely important and crucial one was recognized by all. We are beginning to see where our efforts can be directed to the greatest advantage to all and are all enthusiastic to get into the game.

The afternoon was given over to a visit to the Billings city water filtration plant on the Yellowstone. This was among the first of the rapid sand plants to be built in the state. It has seen continuous service since its installation and is a model of its kind. Mr. Willett explained in detail his operations and told of many difficulties met and conquered.

F. L. LaMotte gave an interesting talk and demonstration of the hydrogen ion theory and control of water purification.

Following this the visitors were taken to the "Rim Rocks" the huge natural wall of rock surrounding the city where a magnificent view of the historic Yellowstone Valley was obtained. It is here that an equestrian statue of "Bill" Hart will soon be placed. On the way up we passed "Boot Hill Cemetery" a spot replete with memories of the good old days when men died with their boots on.

The Friday evening session was given over to a discussion of the best form of organization for the municipal water department. This was led by C. A. Becraft of the Miles City water department. The discussion by practically all present was lively and showed the need of some remedies for existing conditions.

The Saturday sessions were opened by the mayor in an address of welcome, the president's response and address and routine matters of business.

We were fortunate in having Beekman C. Little, secretary of the parent association, with us for conferences and discussions. We regretted his inability to reach Billings until late Friday night but made good use of him on Saturday.

In the afternoon W. M. Cobleigh, of the State College of Agriculture and Mechanic Arts, discussed the subject of the corrosion of pipes by water within and without. The discussion which followed indicated that this was frequently met with in our territory.

Mr. Little told of the activities of the parent association and of the relation of our section to the whole organization.

By the time the dinner was concluded Saturday evening there was no dissent to the opinion that a very successful meeting had been held.

Officers elected for the coming year are: President, John Hall; City Engineer, Choteau, Montana; vice president, Jos. L. Schmit, City Engineer, Lewistown, Montana; secretary-treasurer, H. B. Foote, Helena, Montana. Lewistown was designated as the meeting place for 1928.

H. B. Foote,
Secretary.

NORTH CAROLINA SECTION

The sixth annual meeting of the North Carolina Section, convened at the Cape Fear Hotel, Wilmington, N. C., Monday, August 23, 1926. The President, J. O. Craig, presided, and H. E. Miller acted as Secretary, due to the recent resignation of Thorndike Saville.

The convention having been called to order by the President, Dr. Sullivan, Pastor of the Calvary Baptist Church of Wilmington, offered the invocation.

The convention was welcomed to Wilmington by the Hon. W. H. Blair, Mayor of Wilmington. Mayor Blair assured those present that the city of Wilmington was exceedingly proud to have them as her guests and that nothing would be left undone to make their stay an enjoyable event. He very aptly phrased it by saying: "Instead of presenting the convention the keys of the city, the gates have

been torn from their hinges, our doors are wide open and we welcome you and are glad to have you with us." President Craig responded to Mayor Blair's address of welcome and spoke in glowing terms of the privilege and anticipation felt by the members of the Water Works Association for their stay in Wilmington.

At the business session of the meeting it was unanimously voted that resolutions on the death of Dr. R. H. Lewis, former Executive Secretary of the State Board of Health, be prepared by the secretary and published in the Section Journal along with a photograph.

It was also unanimously voted that pamphlets containing the report of the Committee on Steam Gauging and Forestation be printed by the Publication Committee and distributed to the members of the Legislature, members of the Section and to other interested parties.

The officers elected for the ensuing year were as follows: C. M. Grantham, President; C. E. Rhyne, Vice-President; H. G. Baity, Secretary-Treasurer; W. E. Vest, Chairman of Nominating Committee. The Water Purification Conference elected A. O. True chairman and G. F. Catlett secretary for the ensuing year.

The above were the only elective offices which were to be filled at this meeting. The Executive Board for the ensuing year is as follows: E. G. McConnell, H. G. Baity, C. M. Grantham, H. E. Miller, G. F. Catlett, J. O. Craig, C. E. Rhyne and W. E. Vest.

Durham was selected as the next convention city. A friendly rivalry developed between High Point and Durham, but since Durham had made repeated requests for this particular convention they received the greater number of votes, while High Point claimed the 1928 meeting. The convention discussed the advisability of holding future meetings in the cities in the central portion of the state in order that travel distances would be equally divided among those members who live in the extremities of the state. It was the consensus of opinion that it would be best to alternate the geographical location of convention cities between the East, Middle and West.

Suitable resolutions were prepared and read, thanking the city of Wilmington for its hospitality and the management of the Cape Fear Hotel for the many courtesies shown the members of the meeting by the hotel. The annual convention banquet, held in the ballroom of the hotel, was one of the most successful yet held and was greatly enlivened by the debate between Messrs. Maffitt and Logan, which was won by Mr. Logan.

The boat ride down the Cape Fear river to Southport tendered the convention by the Manufacturers Association was a most enjoyable event. A smoker was held aboard the steamer for the men, while the ladies were entertained at bridge and both ladies and men enjoyed the dance.

The convention was very happy to have a number of out of the state guests, who were welcomed in due and ancient form. Among these might be mentioned Beekman C. Little, of New York City; James E. Gibson, of Charleston; Mr. Bowers, of Newport News; Mr. Chapman, of Camden, S. C.; Mr. Simmons of Laurens, S. C.; and Mr. Clark of Nashville, Tenn.

ABSTRACTS OF WATER WORKS LITERATURE

Frank Hannan

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of issue, and 16 to the page of the Journal.

Preliminary Index to River Surveys Made by the United States Geological Survey and Other Agencies. B. E. Jones and R. O. Helland. U. S. Geol. Survey Water Supply Paper **558**: 108, pp., 1926. Gives data for each State, Alaska, and Hawaii, in regard to maps and profiles of streams surveyed by Federal Geological Survey, other Federal bureaus, and State organizations, with notes as to source of data, scale, contour interval, extent to which topography is shown, and other features. Areas covered by standard topographic maps of the Geological Survey are shown on insert map and another map shows in considerable detail boundaries of drainage areas in the United States.—*David G. Thompson.*

Water Power and Irrigation in the Madison River Basin, Montana. J. F. Deeds and W. N. White. U. S. Geol. Survey Water Supply Paper **560-A**: pp. 1–30, 1925. Data in regard to precipitation, stream flow, irrigation, and power possibilities in Madison River Basin. Annual water supply is more than 1,400,000 acre-feet. Capacity of power plants now installed is 18,000 horsepower, with reservoir capacity of 386,000 acre feet. Undeveloped power resources estimated at 136,000 horsepower.—*David G. Thompson.*

Water Levels in San Gabriel Valley. Harold Conklin. Map with appended text, California Division of Water Rights, 1926. A valuable map showing water level contours in San Gabriel Valley as in December, 1925, and January, 1926, with brief text describing conditions. Key wells which have been measured for more than 20 years show that in some places in December, 1925, the water level was from 4 to 241 feet lower than in 1904, although the latter year completed a drought more severe than the recent dry period. Some wells showed practically no change in level.—*David G. Thompson.*

Discharge Records of North Carolina Streams, 1889–1923. North Carolina Dept. Conservation and Development Bull. **34**: 405 pp., 1925. A compilation of stream flow records for 39 years, prepared in coöperation with U. S. Geological Survey. An innovation in reporting such records is introduced in this volume, namely the publication of the mean weekly discharge for each week of the entire period covered by the record, in addition to the usual monthly discharges. For several streams graphs show weekly duration curves for average

and minimum years. A map of the State shows boundaries of drainage basins, locations of gaging stations, and water power developments of more than 1000 horsepower.—*David G. Thompson.*

Principles of Rate-Making WM. M WHERRY. Jour. New Eng. Water Works Assoc., **40**: 3, 249, September, 1926. Brief review of questions raised and disposed of in water-works cases since January, 1925. Fundamental principle is that company has a right to fair return on fair present value in addition to operating costs and taxes. Also customers are not to pay more or less than fair value of service rendered them. If service is poor, rate may be fixed contrary to the first principle Difficulty is encountered in determining fair present value of property Estimation of cost to reproduce system at present prices, less accrued depreciation, fairest method. Value of paving over mains is disputed. Percentage or split-inventory method may be used where there is a complete inventory record, although there is tendency to value too low. Out of 17 cases, 12 were originally valued too low by commissions; of these, 5 appealed to courts and secured full valuation; four others were subsequently correctly valued. Structural overheads have been generally accepted by the courts in figuring rates, but going values are not generally accepted due to lack of proof. Value of assembled real estate is sometimes much more than that of isolated tracts, but this fact is not often recognized. Water rights, which are peculiar to water companies, are hard to evaluate. Right of appropriation of water from lower riparian owners has a value. Depreciation is hard to determine, the straight line method being commonly used, but actual proof being more frequently required than heretofore. Excess building for expansion purposes should be liberally included. "Rate of return for water utility should be based on market value of money, the fair value of the property, the amount of the fair value over the actual investment, the financial history as to the payment of dividends, the amount of surplus invested in plant equipment, and the general history and record of financial operations and service rendered." Operating expenses have been held by different courts to include cost of rate litigations and franchises, unusual expenses due to emergency pumping, cost of changing mains due to paving, rentals for leased property, payments for water diversion, federal taxes, and increase in local taxes subsequent to rate case valuation; while, on the other hand, athletic club dues, personal fees of employees, advertising, cost of maintaining unused property, and surveys for additional water supplies have been excluded. Fees for tapping have been unfairly included in revenues. Rates should be fixed on cost analyses without discrimination. All consumers should be charged the same and services should be metered. Fire protection services can be most fairly charged on the inch-foot basis or on the capacity of the supply mains. Water company cannot be required to expand into inadequate territory without a guarantee of fair revenue. Service however must be supplied inside the franchise territory. Excuse of inadequate rates for lack of extensions not upheld when company failed to apply for higher rates.—*W. U. Gallaher.*

Some Random Notes on Water-Works Practice Abroad. C. W. SHERMAN. Jour. New Eng. Water Works Assoc., **40:** 3, 297, September, 1926. Average consumption in Europe is from 15–35 U. S. gallons per capita per day. Pressure in most cases is very low, especially in England where house tanks are used. Mains are chiefly of cast iron and much smaller than in America, the network pipe being about 4-inch. In Italy, pipes of asbestos and Portland cement are being used. Linings of one-half inch cement and of a combination of asphalt and ground rock are being put in pipe to prevent corrosion. Pipe patterns are not standardized. In the case of French ball and spigot type, the bell has no shoulder, the lead groove being small and semicircular, while the spigot end has a heavy bead. In order to use lighter material and localize breakage the French are shrinking rings on pipes. Corrosion and tuberculation of cast iron pipe not serious problems in France, Belgium, and Holland, but English Lake District, Wales, and Scotland have considerable trouble therefrom. Jointing compounds are not used to any extent, but joints with rubber packing rings are common. Spacing at end of pipes, about one-fourth inch from spigot end to bottom of bell, is universal practice. Pipes are laid about 3½ feet deep in England and 3 feet, or less, in France. Small pipes are gated with solid wedge type gates at each end of block while larger ones may have gates a mile apart. Hydrants are of the flush type with markers on adjoining fences or buildings. Service taps are made in top of pipe, frequently without a machine for tapping under pressure. Lead service pipes are used entirely. Meters are prohibited in London. Holland has some meters of the inferential type. London water department has a very efficient survey department for location of leaks with special gate and service men. London's new Queen Mary storage reservoir for Thames water has capacity of 8100 million U. S. gallons, has perimeter of 4 miles, and is 36 feet deep. Holland gets water from wells which must be carefully guarded from salt sea water.—*W. U. Gallaher.*

Theory and Use of Thermit Heat Units in Relieving Ice Conditions. H. T. BARNES. Jour. New Eng. Water Works Assoc., **40:** 3, 312, September, 1926. Large ice packs and frazil ice have been broken up by means of thermit. Better than dynamite because it actually burns ice with intense heat generated. Explosion wave is slow. Does not harm concrete structures, turbines, etc., in vicinity of operation.—*W. U. Gallaher.*

Head Losses in Rapid Sand Filters at Cambridge, Mass. R. G. TYLER, W. A. DANIELSON and M. LEBOSQUET, Jr. Jour. New Eng. Water Works Assoc., **40:** 3, 322, September, 1926. Results of experiments on rapid sand filters show: (1) head losses due to sand friction unimportant compared to losses due to clogging; (2) sand is graded according to size with proper washing and gradation is necessary for proper functioning of filters; (3) effective filtering stratum consists of floc layer and supporting fine sand layer; (4) below 0.5 foot sand is of slight value in removing solids; (5) small uniformity coefficient for given effective size, as is usually specified, is not so highly important, since uniform grading off is desirable; (6) uniformity coefficient of top 3 inches of sand after specified washing would be good method for specifying sand; (7)

effective size may be larger where floc is coarse, or detention period short, than when floc is peptized; (8) runs vary with coarseness of floc; (9) coarse floc is retained on surface of sand while fine floc is removed in voids; (10) sand depth may possibly be decreased, if there be rapid grading off of sand; (11) upper 0.05 foot filter surface breaks through in numerous cracks which increase effective surface area of filter; (12) negative pressure occurs first at about 0.50 foot depth and extends downward, but eventually upward to within 0.20 foot of surface; (13) greater positive head might minimize air binding and give longer runs; (14) sudden increases in positive head compacted sand giving sudden increases in head loss; (15) aluminum sulfate floc more completely removed by sand surface than sodium aluminate floc; (16) effective size better method for comparing filter sands than surface modulus or specific surface.—*W. U. Gallaher.*

Purpose of the Cast-Iron Pipe Publicity Bureau. T. F. Wolfe. Jour. New Eng. Water Works Assoc., **40:** 3, 345, September, 1926. Publicity to promote new water works systems, encourage proper design of water works, interest citizens in municipal water works systems, and point out advantages of cast-iron pipe. Bureau also collects data on failures etc. and has a technical committee to work out specifications for cast-iron pipe. A handbook is soon to be published.—*W. U. Gallaher.*

Compensating Reservoirs and Diversion of Water. C. M. Saville. Jour. New Eng. Water Works Assoc., **40:** 3, 352, September, 1926. Most equitable method of settlement for diversion of water is by compensation in kind by methods which will simulate as nearly as possible the average dry year run-off of stream which has been diverted. Lower riparian owners usually prefer water to money settlement, a price being hard to set in most cases. After court action, three billion gallon reservoir has been built by City of Hartford on branch of Farmington River to compensate for water diverted from one of its tributaries for city use. Gates are operated by city employees under direction of riparian owners. Arrangement has been very satisfactory to all parties. X. H. Goodnough in 1922 established principle of utilizing wasted flood flow for industrial purpose. Providence, R. I., in 1925 instituted method of daily allocation of water from its water supply reservoir to mills below as part payment for diversion damages, allocation decreasing each year. Appendix I. Data on diversion settlements. Appendix II. Agreement between City of Hartford and lower riparian owners. Appendix III. Second agreement between above parties specifying method of operation, rights of each party, etc.—*W. U. Gallaher.*

Centrifugal Pump Specifications Should be Complete. C. C. Brown. Power Plant Engineering, **30:** 18, 996, September 15, 1926. "Characteristics should be studied for each installation and all terms used in specifications defined." In specifying performances and comparing designs define commonest terms, such as 'power' and 'efficiency.' Efficiency depends on favorable combination of head, capacity, and speed; the smaller the impeller and the higher the rotative speed, the higher the efficiency. Best to have high

average efficiencies over wide variations of head and capacity. Brake horsepower curves at maximum at rated head and capacity. Prime importance in motor driven pumps.—*W. U. Gallaher.*

Flow Measurements With The Flat Plate Orifice. Power Plant Engineering, **30**: 18, 997, September 15, 1926. "Simplified formulae and coefficients facilitate use of flow meter for temporary or portable use in air, steam, and water measurements." Principle of flat plate orifice same as that of venturi tube and of flow nozzle. Monel metal best material for orifice. Two pressure taps should be exactly located, preferably in side of pipe, the upstream tap one pipe diameter above orifice and downstream tap at "vena contracta," location varying with orifice ratio. Inches of water most convenient unit to use for differential head. Instruments easily recalibrated and new constants calculated. Two sets of calibration figures given, one for steam and water, and one for air. For compressible fluids, pressure differential should be kept below 1.5 per cent of initial pressure. Keep orifice installation 10 or 12 pipe diameters from elbows and bends.—*W. U. Gallaher.*

Motor Operated Valves Aid Plant Operation. Power Plant Engineering, **30**: 18, 1001, September 15, 1926. Principal details of valves and controls and costs of installing are given, and several interesting applications are discussed. Valves should work perfectly, particular attention being paid to stems and their connection with disc. Friction minimized by ball bearings while machined guides in body and disc are essential. Valve should be protected with shear pin or adjustable friction clutch. Motor drive consists essentially of motor, reduction gears, and limit switch. Provision should be made for hand operation; usually by a clutch arrangement. Controls may be at numerous points, or at a master station, and there should be valve opening indicators. Closing time of valves depends on size of valve, pressure involved, and desire of user. Higher closing speed means less torque available.—*W. U. Gallaher.*

De-Concentration of Water Effects Marked Savings. J. O'Brien. Power Plant Engineering, **30**: 23, 1275, December 1, 1926. Deconcentration of boiler water by addition of soda ash and filtering has reduced renewals from two per year to one in four years and boiler washings from one in 105 days to one in 35 days, with a net saving of $1,402.96 per year on an investment of $700.—*W. U. Gallaher.*

Trend Toward Better Water Supplies. Wellington Donaldson. Engr. & Contr., **65**: 495–7, 1926. Muni. & County Eng., **71**: 109–12, 1926. A general discussion of some of the recent developments for water supplies.—*C. C. Ruchhoft.*

Water Hyacinth. Anon. Engr. & Contr., **65**: 514, 1926. Twelve acres of water hyacinth were removed from a lake with a crane equipped with a special fork bucket with excellent success by the Park Board of St. Petersburg Fla.—*C. C. Ruchhoft.*

Conservancy Districts and Their Possibilities. Paul Hansen. Engr. & Contr., **65**: 539–42, 1926. The Illinois legislature created a law authorizing the establishment of conservancy districts having a unified control of the pollution of an entire river system and permitting a unified development of a water supply. The conservancy district may build sewage disposal works from the proceeds of bond issues payable out of general taxation spread over all of the assessable property of the district. Water supplies developed by the district are placed on a self-sustaining business-like basis, for the water must be sold by meter and rates must be fixed to pay all operating expenses and fixed charges, and all earnings can be used only for improvement or reduction of rates. The conservancy district is governed by five trustess with overlapping terms appointed by county judges. A conservancy district has been formed for the Fox Valley.—*C. C. Ruchhoft.*

Unique Features of Omaha Pumping Station and Filtration Plant. Anon. Engr. & Contr., **65**: 565–67, 1926. The Florence Pumping Station of the Metropolitan Utilities District at Omaha, Nebr., is equipped with two Worthington split casing double suction volute pumps connected in series with a capacity of 50,000,000 gallons per day against a head of 280 feet, and driven by a 3000 h.p. G.E. condensing type steam turbine. In the two pumping stations at Omaha, five water wheel driven pumps are used. The water wheel driven wash water pumps deliver 850 gallons per minute against a 60-foot head at 450 r.p.m. and require 550 gallons per minute at a net head of 190 feet for their operation. The water required to operate the pumps is discharged into the wash water reservoirs into which the pumps also discharge. It is claimed that this method of pumping wash water is $2,500.00 per year under any other method.—*C. C. Ruchhoft.*

New Well System at Havelock, Neb. Fred C. Hall. Engr. & Contr., **65**: 576–7, 1926. The old well system consisting of six 6-inch wells was only able to produce 320 gallons per minute which was not sufficient for the needs of the city. Ten test wells were drilled and the one tapping the best water bearing gravel was chosen as the site for the permanent well. A 38-inch iron casing and an 18-inch inner casing and iron screen was put into the new well and gravel was put into the space between the two casings. The completed well produced 610 gallons per minute.—*C. C. Ruchhoft.*

Scientific Control of Alum Feed. A. B. Cameron. Engr. & Contr., **65**: 567, 1926. The installation of a venturi tube meter on the raw water line and of two Gaunt type dry feed machines in the old rapid sand filtration plant at Bucyrus, Ohio, reduced the alum consumption from 100 to 60 tons per year, or to less than 2 grains per gallon, with no decrease in efficiency of the plant and effected a saving of 90 per cent of the investment the first year.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Water Softening at Columbus, Ohio. Charles P. Hoover. Entr. & Contr., **65**: 498–500, 1926. The split treatment process of water softening, in which an over treatment with lime and soda ash is given to as large a portion of the

hard water as possible to get the maximum reduction in hardness and the excess lime and soda ash then neutralized with hard water, is used at Columbus. This process is more effective than the ordinary method though not so effective as, but cheaper than, overtreatment. 26.4 m.g.d. were softened from 298 to 92 p.p.m., a reduction of 69 per cent, and filtered. The cost of lime, soda ash, alum and chlorine was $20.98 per million gallons.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

Algae Growth in Impounding Reservoirs. A. B. CAMERON. Engr. & Contr., **65**: 618–20, 1926. Dosing impounding reservoirs once or twice each summer month with from 0.25 to 0.40 p.p.m. of copper sulphate was effective in preventing short filter runs, use of excess wash water, and bad tastes at Bucyrus, Ohio. The necessity of dosing the reservoirs was determined by the noting of litteral organisms in the plant, length of filter runs, and frequent microscopical examination.—*C. C. Ruchhoft.* (*Courtesy Chem. Abst.*)

How Sun Spots Affect the Level of the Great Lakes. HALBERT P. GILLETTE. Engr. & Contr., **65**: 466–7, 1926. Gillette explains that the 3 per cent more heat which is emitted from the sun during years of greater sun spot activity results in greater evaporation of sea water which later on results in greater rainfall on the continents; and presents a chart showing the relationship between sun spot frequency and lake levels.—*C. C. Ruchhoft.*

Excavation in Water Bearing Sand. R. C. WILSON. Engr. & Contr., **65**: 555–8, 1926. The site of the pumping station and part of the filter plant for Palm Beach and West Palm Beach was occupied by Lake Clear. A dike of fine sand was built around this site by means of an electrically driven hydraulic dredge. A 12-inch centrifugal pump, delivering 3 million gallons per day from three existing wells tapping a coarse shell stratum about 90 feet under the surface of the lake, was used in draining this area. This system of subsurface drainage very successful and saved much time and money.—*C. C. Ruchhoft.*

Los Angeles Raises Water Rates for Domestic Use and Irrigation. Eng. News-Rec., **97**: 94, July 15, 1926. Following new schedule per 100 cubic feet of water consumed in one month was recently adopted in Los Angeles: First 10,000 cubic feet, 13 cents; next 40,000, 11 cents; next 50,000, 9 cents; all in excess of 100,000, 7 cents, provided that minimum monthly rates shall not fall below the following: for ⅝-, ¾-, and 1-inch meters, $1; 1½-inch, $1.50; 2-inch, $2; 3-inch, $3; 4-inch, $4; and 6-inch, $6. The former rate was 10 cents per 100 cubic feet compared with average maximum rate of 18 cents for 183 of the largest and most representative American cities.—*R. E. Thompson.*

Muskogee, Okla. Eng. News-Rec., **97**: 108–9, July 15, 1926. Changing conditions, due to tourists and campers throughout the watershed of Grand River, from which city water supply is derived, are making necessity of filtration more and more pronounced. Proposed $225,000 bond issue for this purpose was rejected by citizens last year. Turbidity is less than 20 for 5 months of year. Total settling storage capacity is 10 million gallons, equiva-

lent to 3 days' supply. Water is treated with 6 pounds of chlorine per million gallons. Services are metered, bills being rendered monthly.—*R. E. Thompson.*

Public Water Supplies in Haiti. Eng. News-Rec., **97**: 109, July 15, 1926. Brief data on public supplies in Haiti. Ten municipalities, including Port au Prince and Pétionville, which have joint works, have public supplies. In addition, the Government has sunk 41 wells in 13 towns and villages.—*R. E. Thompson.*

Progress and Methods in the New Cascade Tunnel, Great Northern Railway. Eng. News-Rec., **97**: 100–1, July 15, 1926. Progress on tunnel outlined briefly and power and tunneling equipment and character of ground described.—*R. E. Thompson.*

Removing Mud Balls from Filter Sand. Martin E. Flentje. Eng. News-Rec., **97**: 369, 1926. Mud balls in filters at Oklahoma City, Okla. were removed by passing the sand through ordinary sand jet discharging against filter wall at cost of $20 per filter. A partial analysis of the balls, which were due to inadequate washing and insufficient carbonation of the lime-softened water being treated, was: moisture 18, acid soluble material 9.5, ignition loss 0.4, and residue 72.1 per cent.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

Chlorination of Water. L. H. Enslow. Pub. Health Eng. Absts., January 30, 1926. From Chem. Abst., **20**: 1290, April 20, 1926. Modern applications of chlorine to the destruction of bacterial life, algae prevention, oxidation of sulfur gases and iron, and in taste and odor prevention are discussed.—*R. E. Thompson.*

Maintenance and Operation of Water Supply Works. W. H. Dittoe, et al. Am. Jour. Pub. Health, **16**: 136–9, 1926. From Chem. Abst., **20**: 1291, April 20, 1926. Pollution of streams is making demand for greater efficiencies in water purification. More careful control by technical service and by state laboratories is advocated.—*R. E. Thompson.*

Antimicrobial Properties of Various River or Sea Waters. Bacteriophage Power. F. Arloing, Sempe and Chavanne. Bull. Acad. Med., **43**: 7 (French); Pub. Health Eng. Absts., Jan. 30, 1926. From Chem. Absts., **20**: 1291, April 20, 1926. Evidences of anti-microbial action of certain river or sea waters have been found. Lytic action of these waters is attributed to presence of multivalent bacteriophage, rather than to nonspecific causes.—*R. E. Thompson.*

Purification of Boiler Feed Water. Wm. E. Smith. Facts about Sugar, **20**: 1168–9, 1925. From Chem. Abst., **20**: 1291, April 20, 1926. Proper cylinder lubrication and efficiency of various types of equipment for removing oil are discussed.—*R. E. Thompson.*

Verdict in Polluted Water Case. John W. S. McCullough. Pub. Health Jour. (Can. Pub. Health Assoc.), **17**: 386–7, 1926. During autumn of 1925 outbreak of typhoid fever occurred in city of Owen Sound, Ont., as result of pollution of water supply, and resident who contracted typhoid fever was recently given judgment for $2,000 and costs against the city. Provincial Board of Health had consistently urged that supply be chlorinated since a previous outbreak in 1916.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

The Water Supply of Vienna and the Possibility of Its Extension. Franz Schönbrunner. Gas u. Wasserfach, **69**: 85–9, 1926. From Chem. Abst., **20**: 1124, April 10, 1926. Discussion of hydrology of vicinity.—*R. E. Thompson.*

Chemical and Chemicophysical Researches on Three Mineral Waters of Aganano (Naples). F. Zambonini, G. Carobbi and V. Caglioti. Ann. chim. applicata, **15**: 434–74, 1925. From Chem. Abst., **20**: 1125, April 10, 1926. Composition and various physical and chemical constants given for three mineral waters. Methods of analysis included.—*R. E. Thompson.*

Turbidimeter for Accurate Measurements of Low Turbidities. J. R. Baylis. Ind. Eng. Chem., **18**: 311–2, 1926. From Chem. Abst., **20**: 1151, April 20, 1926. Simple apparatus described in detail for comparing turbidity of liquids with that of samples of known turbidity. Known standards are determined with Jackson candle turbidimeter. Method described readily detects turbidity of 0.1 p.p.m., but is accurate only for turbidities less than 2.—*R. E. Thompson.*

Vary Mix Design for Concrete to be Used at Different Ages. R. T. Giles. Eng. News-Rec., **97**: 510–1, 1926. Results of comparative tests of concrete made with and without accurate control of water are given. With accurate control strength was greater by 77 per cent at 7 days and by 30 per cent at 28 days. In a series using fine aggregate only, of 21 gradations, the 7-day strengths were higher in every case with accurate control, while in some cases equal strengths were obtained at 28 days. One-year specimens will be tested in each series. Conclusion drawn from the experiments include (1) that fineness modulus is not a true measure of gradation but an indication only, and (2) that for ultimate strength accurate control of fine aggregate is of much more importance than accurate control of water.—*R. E. Thompson.* (*Courtesy Chem. Abst.*)

The Production of Metal Coatings on Iron. Kröhnke. Gas u. Wasserfach, **69**: 21–4, 48–52, 1926. From Chem. Absts., **20**: 1049, April 10, 1926. Description with extensive bibliography of electrolytic, spray, vapor condensation, and molten bath processes for producing coatings of tin, zinc, lead, nickel, copper, cobalt, chromium, etc., on iron.—*R. E. Thompson.*

Chloramine Treatment of Water in the Field. C. H. H. Harold. J. Roy. Army Med. Corps, **46**: 115–9, 1926. From Chem. Absts., **20**: 1124, April 20,

1926. In field tests mono- and dichloramine gave satisfactory water with better taste than did chlorine.—*R. E. Thompson.*

The Significance of Bacteriophage in Surface Water. LLOYD ARNOLD. Am. Jour. Pub. Health, 15: 950, 1925. From Chem. Absts., 20: 1125, April 20, 1926. Surface waters containing a high degree of domestic sewage contain bacteriophagic substances in direct proportion to amount of pollution. These phages cause lysis of pathogenic bacteria, thus reducing probability of epidemics. They also influence bacteriological examination for pathogens in these waters. Use of bacteriophages in filtration is suggested.—*R. E. Thompson.*

NEW BOOKS

Public Ground Water Supplies in Illinois. G. C. HABERMEYER. Ill. State Water Survey Bull., 21: 710 pp., 1925. The greater part of this voluminous report consists of detailed descriptions of nearly 400 ground water supplies in Illinois, distribution of which is shown on a map of the State. For most supplies there are data in regard to history of the systems, pumping station equipment, number of services, and meter rates. The well systems are described in somewhat greater detail, with well logs where available, notes on yields and drawdown, and miscellaneous information. For practically every supply there are one or more chemical analyses, expressed in three forms, namely determinations of elements or radicals in parts per million, and hypothetical combinations in both parts per million and grains per gallon, with notes on the effect of the water on service fixtures. Some unusual conditions to be discovered by a study of the report may be mentioned. One well, at Aledo is 3165 feet deep, and many wells are from 1000 to 2000 feet and more. Although the yield of rock wells in most localities ranges from only a few gallons a minute to a few hundred, at Aurora wells in excess of 2200 feet deep yield 1000 to 1400 gallons a minute and a 1503-foot well at Rockford yields 1400 gallons a minute. At the latter place 2.75 m.g.d. are obtained by pumps set in a shaft 79 feet below the station floor, with tunnel connections to eight wells. The water in many localities is rather highly mineralized and hard. Many of the systems supply water with total solids in excess of 1000 parts per million and a few, with even more than 2000 parts. Water containing total solids as high as 5021 parts per million apparently was used for some years as the public supply for Barry, and part of the supply for Mount Sterling contains about 3300 parts per million Total hardness in a majority of places is probably between 250 and 500 parts per million, reaching as high as 850 parts per million at Western Springs, with total solids of 1053, and as low as 52 parts at Bureau, where the total solids are 1931 parts per million. Water from an unused well at Flora contained 61,026 parts per millon of total solids and 6946 parts of total hardness. Unfortunately the report does not contain any general summarizing of facts relating to various phases of ground water development in different parts of the State, such as distribution of the principal water-bearing formations, depth to, yield of, and quality of water obtained from them in different localities. Despite the lack of a summary,

however, the report will prove of great value; indeed its full worth may not be realized until some years hence, when, in planning for additional supplies, data will be needed in regard to the effects of past pumping—data the value of which town officials often fail to realize and do not preserve. The Illinois State Water Survey has performed a useful service in recording so much data in a form easily available for future use.—*David G. Thompson.*

Waterworks Handbook of Design, Construction and Operation. Compiled by Alfred Douglas Flinn, Robert Spurr Weston and Lathrop Bogert, Third Edition, 1927. McGraw-Hill Book Co., Inc. The first edition of this book was published in 1916. From the standpoint of appearance and serviceability the new volume is an improvement over the first edition by the use of maroon colored buckram covers in place of the flexible dark blue binding.

In preparing the third edition the authors have so broadened the scope of the original text as to make it of value in other branches of engineering outside the water works field. It is still, however, primarily a book for waterworks men, but the added material therein enhances its value to them. The text is arranged in logical sequence as in the earlier additions by grouping under natural headings, as: Sources of Water Supply; Collection of Water; Transportation and Delivery of Water; Distribution of Water; Character and Treatment of Water and Hydraulics and Materials. This arrangement is most convenient for ready reference, since the topics discussed under each heading are similarly arranged along natural lines.

To keep abreast of the advance made in the waterworks branch of engineering practice during the past ten years the authors have added considerable new material to the book and rewritten and rearranged other parts. Some of the text in the earlier editions has been omitted. The volume is full of pertinent and valuable information not alone to the practising engineer, but to the nontechnically trained personnel of the water department.

Since it is impossible to include in one volume all the valuable material in the waterworks field the authors have placed at the end of each chapter extensive bibliographies so that the reader, should he desire to delve deeper into any of the many phases of this branch of engineering, has at his disposal a large number of references as a guide for further research.—*George L. Hall.*